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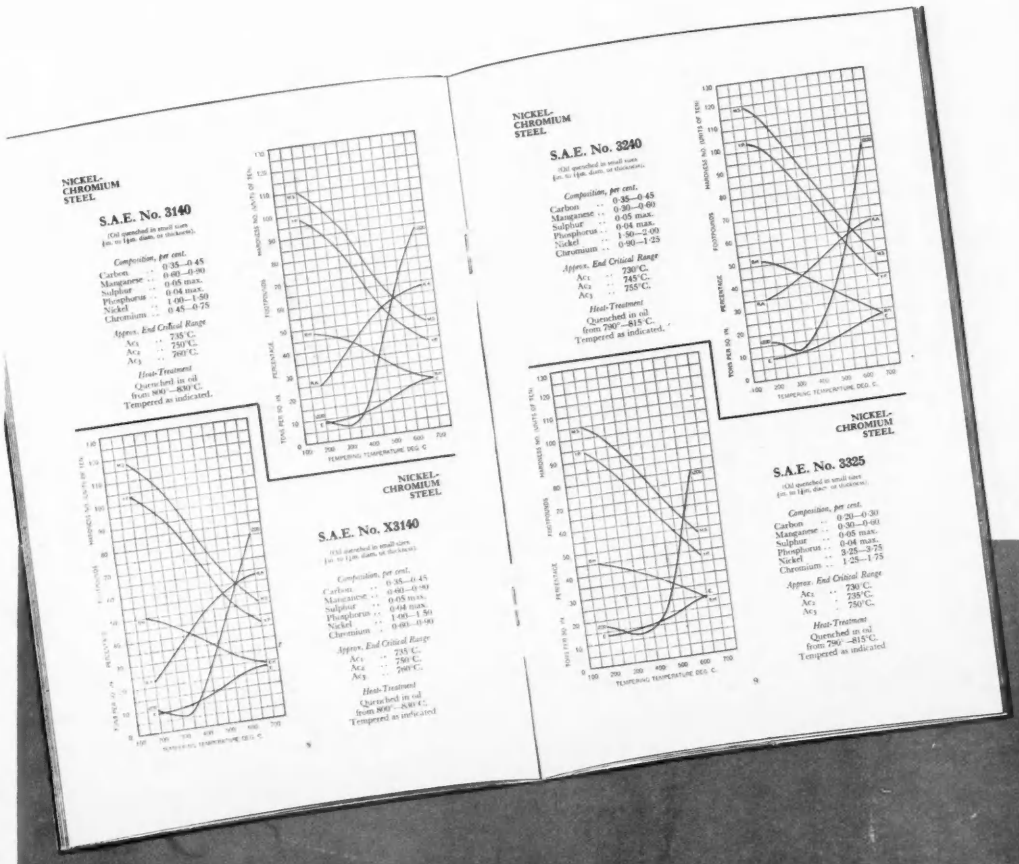

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A Seven-Day Journal

The Success of the Blockade

AT a luncheon at the Dorchester Hotel, last week, arranged by the National Defence Public Interests Committee, Mr. Hugh Dalton, the Minister of Economic Warfare, spoke on the success of the blockade against Germany and Italy, and said that in the first year of the war it had achieved remarkable success. Germany, and still more Italy, was seriously deficient in many of those key commodities without which modern war could not be carried on. Oil, ferro-alloys for hardening steel, rubber, lead, copper, textiles were all short, and he hoped would soon be shorter. Since the war began the goods seized by order of the Contraband Committee alone had amounted to more than 750,000 tons. To this total must be added a still larger total of goods which would have started on their way to the enemy, but never did so. A Committee of Ministers, of which he was a member, was now engaged on a close study for preventing large stocks of goods needed by the enemy from accumulating in neutral countries. An exhaustive survey of the principal areas affected had now been completed and of the principal commodities, of which large surpluses exist. The lines of policy to be pursued were clear, but to succeed fully they required the effective co-operation of a number of countries, and notably of the British Commonwealth, the U.S.A., and the Latin American Republics. He saw in this development the beginning of economic planning on a world-wide scale. Oil, he said, was a key commodity, and he was informed by his expert advisers that the Nazis had now nearly exhausted all the stocks of oil which they had captured in the occupied territories. If, therefore, they are to move anything in these territories, they will have to supply them with oil from their own synthetic plants or from Eastern Europe. There was some talk of an impending famine in Europe, but in Europe as a whole there would be no famine this winter. There was enough food, Mr. Dalton said, to go round to avert starvation if it was properly shared out.

A Scientific Advisory Committee

IN a Journal note of January 5th we recorded the creation of an Advisory Council on Scientific Research and Technical Development, which was formed in order to ensure the co-operation of scientific workers with the Ministry of Supply in the national war effort. On Thursday, October 3rd, it was announced from Downing Street that in order to ensure the continuance of the fullest co-operation between scientists and the Government, the Lord President of the Council, after discussion with the Royal Society, has, with the approval of the Prime Minister, appointed a Scientific Advisory Committee with a Secretary from the Cabinet Secretariat. The members of the Committee are: Lord Hankey, the Chancellor of the Duchy of Lancaster, who will act as Chairman; Professor Sir William Bragg, President of the Royal Society; Dr. E. V. Appleton, Secretary of the Department of Scientific and Industrial Research; Sir Edward Mellanby, Secretary of the Medical Research Council; Sir Edwin Butler, Secretary of the Agricultural Research Council; Professor A. V. Hill, Physical Secretary of the Royal Society, and Professor A. C. Egerton, Biological Secretary of the Royal Society. The terms of reference of the Committee are: "To advise the Lord President on any scientific problem referred to them; to advise Government Departments when so requested on the selection of individuals for particular lines of scientific inquiry, or for the membership of committees on which scientists are required, and to bring to the notice of the Lord President of the Council promising new scientific or technical developments which may be of importance to the war effort."

Deep Shelters in London

IN a recent letter to *The Times*, Mr. R. R. Stokes, the chairman and managing director of Ransomes and Rapier, Ltd., points out that it seems likely that public opinion will force the Government to embark on a scheme—long overdue—for the construction of deep bombproof shelters. As far as London itself is concerned, such a scheme, he says, should bear some relation to after-war utility. On March 1st, 1939, Mr. Stokes, speaking in the House of Commons, urged Sir John Anderson to build deep tunnels 60ft. down in the London clay, which would serve two purposes, providing immediate shelter for the whole of London's population and forming the basis of a future network of underground roads, for the relief of traffic congestion after the war. Having regard to the asset value of the tunnels after the war is over, Mr. Stokes suggests that the cost is almost negligible. It is calculated by competent engineers, he states, that a mile of tunnel, 12ft. in diameter, lined with cast iron or reinforced concrete, and with a concrete base, could be built for £180,000, including latrines, drainage and ventilation. Such a tunnel would accommodate 10,000 people. Four hundred miles would take the whole of London's remaining population, and the cost, £72,000,000, would be equal to the cost of nine days of war, with the difference that there would be an asset value when the war was over. The cost of carrying out the Bressey Report for the relief of traffic congestion was, Mr. Stokes recalls, estimated to be £128,000,000, but the Deputy Chairman of the Finance Committee of the London County Council stated that it could not be proceeded with on account of the expense, especially having regard to the fact that £80,000,000 had to be paid in compensation to landlords. Even if the deep tunnel scheme should not be completed by the time the war is ended, there is, Mr. Stokes claims, no reason why it should not be proceeded with. There would, he points out, be no waste; in fact, it might prove to be London's chief asset, and thousands of miners are ready and waiting to undertake the work. Mr. Stokes suggests that what the Government should do is to collect a panel of consulting engineers and contractors used to working in London's underground, and give them authority to get on with the job. By the end of March next year one-third of the job would be completed and bombproof shelters would be provided for one million and a-half people.

London's Export Trade Carries On

A STATEMENT which was issued by the Board of Trade on Monday, October 7th, shows that if the intention of the German Air Force was to impede seriously the commercial and industrial activity in the Greater London area during a month of intensive day and night bombing, it has signally failed. The replies which have been received from member firms of export groups and trade associations in the area, in response to inquiries made by the Board of Trade, give conclusive proof that the overwhelming majority of works in the area which are engaged in the export trade are keeping up their full production and are making deliveries to contract time for dispatch to their customers overseas. Works which are situated in the most heavily bombed areas and which have been repeatedly hit have been able to adapt themselves quickly to "Front Line" conditions. A typical example is afforded by a works in the neighbourhood of the docks, which employs 1200 workpeople. This works has been bombed eight times within three weeks, and practically every known kind of bomb has fallen upon one or other section o the works. Among the departments destroyed were a large carpenters' shop, the paint shop, the general stores, and a metal working shop, while the main generating plant was put out of action. Despite this heavy damage the managing director of the company owning the works was able to report only two days after the latest raid that as a consequence of their resourceful organisation the output of the firm was already back to nearly 70 per cent. of the normal and that it was daily increasing. Another works, which is situated in the same area, reports that within thirty hours of the almost total destruction of its premises production for export orders had been transferred, under a prearranged "shadow plan," to another factory in the North of England, and that output was being fully maintained. The London Chamber of Commerce has a membership of some 9000 firms which are engaged in every branch of light and heavy industry. Fewer than twenty of these firms have notified the Chamber of the necessity to move to temporary addresses owing to damage caused to premises by bombing. All the firms are continuing to deliver the goods required for home and export orders.

British Corporation Register Staff Changes

AT the recently held October meeting of the British Corporation Register of Shipping and Aircraft in Glasgow, the Committee of Management regretfully accepted the resignation of the Chief Surveyor, Mr. J. Foster King, C.B.E., which will take effect on November 30th, 1940. Mr. King, who joined the staff as leading Surveyor on December 1st, 1890, has served the Corporation for fifty years. He became Assistant Chief Surveyor in March, 1892, and has held his present appointment for thirty-seven years, a record unsurpassed, we believe, in the annals of ship classification. His record of achievement is widely known and his classic contributions to naval architecture, together with his outstanding share in the emancipation of shipping from hampering restrictions of every description, are a lasting memorial of his labours in the public service. Mr. J. L. Adam, the present Assistant Chief Surveyor, has been appointed to succeed Mr. Foster King, and Mr. G. M. Sellar, B.Sc. (Eng.), the Principal Engineer Surveyor, will become Chief Engineer Surveyor. Mr. Adam joined the British Corporation staff in 1911 and six years later he was promoted to executive rank. In 1927 he succeeded the late Mr. Benson Taylor as Assistant Chief Surveyor. Mr. Adam is well known to the present generation of shipowners and shipbuilders. His contributions to the practical side of his profession include numerous papers on the care and repair of ships. and he is a recognised authority on welding research and development as applied to ship construction. Mr. Sellar, who is to become Chief Engineer Surveyor, is a graduate of Glasgow University and has made a special study of internal combustion engines. Although he is a comparatively young man, his ability and sound judgment led to his selection in 1938 for appointment as Principal Engineer Surveyor to the Corporation, and his promotion is an indication of the confidence reposed in him by the Committee of Management.

London Transport Emergency Engineering Measures

A COMMUNICATION issued from the headquarters of the London Passenger Transport Board on Thursday, October 3rd, referred to the measures which are being taken by the civil engineering staff of the London Transport Board in order to prevent the air attacks of the enemy from disorganising London's public transport services. Night and day, the war emergency headquarters of the Chief Civil Engineer are in constant touch with seventeen posts and innumerable private telephones, which link up the London Transport system. Immediately at hand at headquarters are charts and maps and drawings dealing with every detail of the railways, such as tunnels, bridges, permanent way and current rails, signalling, telephones, lighting, clocks, all buildings, drainage and ventilation plant and tramway tracks. In case of air raid damage the work proceeds smoothly. On receipt of a message that high-explosive bombs have fallen at a certain part of the line the engineer on duty immediately gets into telephonic communication with an inspector at the nearest point. The inspector and his men immediately go to the spot to investigate, although at the time bombs and fragments of anti-aircraft shells may be falling. In the past few weeks many such calls have been made, and the men have never failed to set out and to make their investigations even in the heaviest raids. Their work has been characterised by coolness and courage in effecting immediate repairs, in removing and clearing up *débris*, and dealing with any emergency condition which may have been discovered. By such means the transport of London is kept running. The London Passenger Transport Board and its staff of engineers and inspectors with their men are to be warmly congratulated on the work they are carrying out.

Examination of Crashed German Aircraft

FOR some time past it has been generally known that there are many dumping places in the South of England where the remains of crashed and fallen German aircraft are assembled for the salvage of metal. Besides machines which are only fit for scrap, the Royal Air Force recovers sometimes Messerschmitt fighters and Dornier and Junkers bombers, which are practically intact or have suffered very little damage. The careful examination of such aircraft by experts on the design and construction of engines, metals, armour, armament, and radio equipment, has revealed to our designers and builders many developments which formerly were German secrets. Thus, performance figures, the details of new inventions, and recent safety and labour-saving devices have come into our hands. Not only have these valuable lessons been learned from the examinations made, but it has been possible to instruct R.A.F. fighter pilots as to the best angle from which to attack German aircraft, and, what is of equal importance, the attack angles at which the enemy can deliver his strongest attack. As to the general construction of enemy aircraft, examination has revealed that, on the whole, German fighters and bombers are constructed of tough and serviceable materials. On the engine side, the metals used are good, but hardly up to the British standard. Some degree of microporosity has been shown in some engine castings. One of the interesting features has been the design of the self-sealing petrol tank, with which many German and British machines are now fitted. In the German design a multi-thickness tank is employed having a capacity of about 280 gallons. The weight is about 4½ lb. per square foot. The outer surface is of vulcanised rubber, with layers of pure rubber below it, followed by a layer of self-sealing rubber-like substance. Below this layer is a leather jacket, which covers the real tank made of fibre. Metal straps are employed to brace the tank. Thin red lines on the windscreens of Junkers dive-bombers are marked at angles of 40 deg., 50 deg., 60 deg., and 70 deg., which, when brought in line with the horizon, enable the pilot to dive at the angle desired. In general, the examination of enemy machines has revealed several technical developments, intended, no doubt, to get the highest efficiency from the types of aircraft adopted by the German Air Force.

Motor Workshops in South Africa

THE successful development of the petrol-driven vehicle has resulted in a tremendous advance in the field of transportation, and in few countries have the benefits been more pronounced than in South Africa. The 13,000 route miles of railways, of course, provide adequate facilities wherever traffic conditions warrant their existence, but in a country so vast and yet so sparsely populated as is South Africa, there must of necessity be many districts where transportation services are essential to development, but where the building of a railway line would not be an economic proposition. Accordingly, the Railway Administration some years ago instituted a system of road motor services to provide transportation in outlying districts. The success of the venture was manifest from the start, and the road motor branch has grown to such an extent that it now operates over 15,000 route miles, carries some 5,000,000 passengers, 600,000 tons of goods traffic, and 1,500,000 gallons of cream annually, and has vehicles and equipment to the value of well over a million pounds.

For such an undertaking, necessitating the use of almost 100 passenger vehicles, 350 dual-purpose vehicles, and 400 trailers, efficient repair depots and workshops are a prime factor, and the Administration has, in consequence, established numerous services garages throughout the country, and large workshops capable of effecting any overhaul or repair, at certain strategic points. The largest of the new workshops is at Langlaagte.

The Langlaagte depot has been designed on the most modern and efficient lines, all essentials being located under one roof. The building, a massive, single-storied reinforced concrete structure, measures 445ft. by 150ft., being laid out so as to obviate all unnecessary movements and to provide the maximum ease of working. An example of the care and thought that went into the design of the lay-out is seen in the location of the gas and electric sub-stations, the gas being brought in at one end of the building where the smith's shop is situated, whilst the electric sub-station is at the other end in close proximity to the many machines and the consequent greater load. Another and perhaps the most important reason for the separation of the gas and electricity is to keep them as far apart as possible in the interests of safety. The building alone cost something like £32,000, whilst the equipment, which includes some of the finest machinery of its kind in the country, accounted for an additional £50,000. It will be noted from the photographs reproduced herewith that the lighting is particularly effective and is well diffused.

Only complete overhauls and major repairs are carried out at the Langlaagte depot, which is responsible for all work of this nature necessary to road motor vehicles on the Eastern and Western Transvaal systems. Running repairs and servicing of the cartage plant, totalling 264 vehicles and approximately 1000 trailers, are undertaken at the road motor workshops at Razerne.

This in itself means a great saving, in that a highly skilled workman engaged on a big repair job need not be continually interrupted to effect some minor adjustment. The many different types of official cars, rail trollies, compressor plants, &c., used by the several railway departments are also repaired at Langlaagte.

No detail that will lead to greater economy and efficiency has been neglected by the road motor branch, and an example of this is seen when major repairs to an engine have to be effected. To avoid withdrawing the complete vehicle from service for the somewhat lengthy time it may take to make the repairs, it is the practice to take the engine out of the chassis and replace it with another so as to release the chassis for duty while the repairs are being effected.

At the Langlaagte depot are concentrated the reboring of cylinder blocks and regrinding of crankshafts for the whole Union. There is no wastage of plant, for should a cylinder block in a vehicle at Cape Town, for instance, need reboring, the block only is sent to Langlaagte, a spare being used at Cape Town in the meantime.

Adjoining the section where repairs are carried out is the machine shop, where parts are manufactured and where much up-to-date machinery is kept fully occupied. Most of the machines are specialised, there being, for instance, a machine for regrindng cam shafts, probably the only one of its kind in the country. There are also grinding machines for general work, high production lathes, &c., as well as special machines which manufacture spring pins and other parts. Electric saws cut bar metal to the required lengths. All of the machines are of the precision type and the motor parts made or repaired are finished to the last detail, so that as much hand fitting as possible will be eliminated when the engines they are destined for are being assembled by the mechanics. All the machines are separately driven by their own electric motors, thus doing away with the need for line shafting and belt drives.

Near the machine shop is a small coppersmiths' shop where gas-fired ovens heat the soldering irons and gas-fired furnaces melt aluminium for castings and body parts. The blacksmiths' shop, which is placed in one corner of the large building, is a scene of great industry with its

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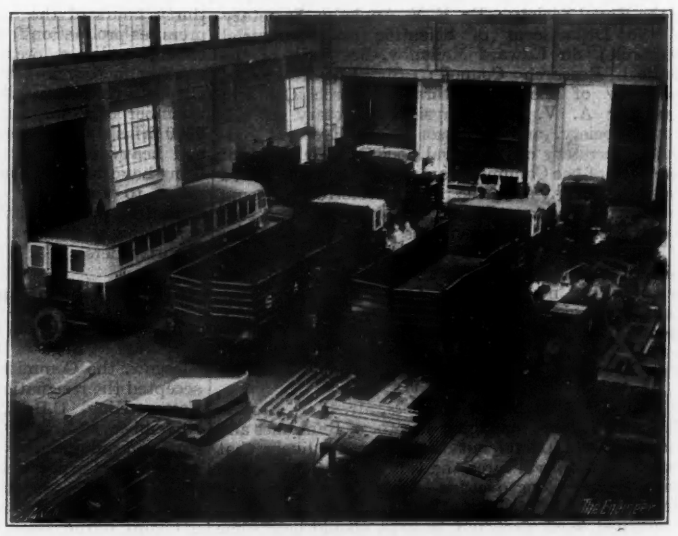
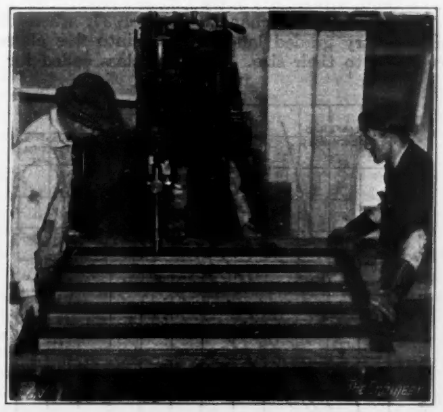
MANUFACTURE OF RAIL TROLLIES



BODY BUILDING SHOP

gas and oil-fired furnaces casting a ruddy glow over everything. Steel is case hardened and springs manufactured and tempered in this shop.

In the welding section, where body members are fabricated, each welder has his own cubicle to work in so that the glare of the arc and the spattering of the sparks will not interfere with other workers. Electric welding machines are extensively employed in the body-building section of the shop, and doors, panelling, and other suitable body parts are in many cases spot welded by power-operated and hand machines. This section is the only place in South Africa to produce all-metal body parts. The power-driven spot-welding machine works at a fairly high speed, and it is almost completely automatic in action, a foot pedal being sufficient to operate it, the machine doing the rest of the work and even timing the length of the weld. In this section, too, are steel-cutting machines which cut the steel to required sizes before it is passed on to folding machines which press it into the necessary shape. As in the other sections of the shop, everything is finished as far as possible before assembling, so that the man on the final job will have to waste no time when erecting. Everything is cut from jigs so that the standardised patterns will always fit without requiring much, if any, alteration. Pneumatic spanners greatly facilitate the work of putting the parts together.



SPOT WELDING MACHINE

An overhead traversing crane spans the whole of one side of the shop. It can lift up to 20 tons and is electrically operated. It is used mainly in the erecting shop for lifting bodies on to and off the chassis. For convenient working the bodies are usually assembled off the chassis, so that the erectors are enabled to work on the floor instead of from awkward or dangerous positions on scaffolding.

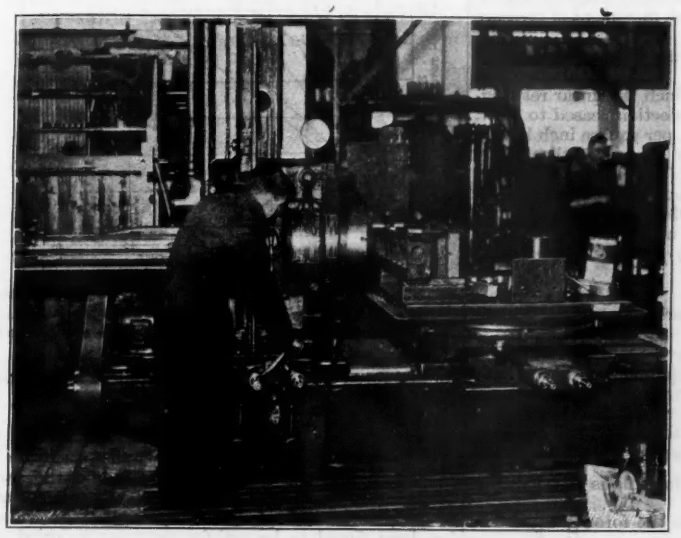
Apart from bus bodies all the rail trollies for the Union are being built at the Langlaagte depot, and, at the moment, sixty-five are in course of construction. Inspection and flying gang trollies are built to a standard design, and it is an interesting process to see them start from practically nothing on the assembly line and finish up ready for the road.

Most of the bodies seen on the road motor vehicles throughout the Union are now built at Langlaagte, where everything from a small light van to a large 10-ton truck can be fabricated and erected. Some of the bigger bodies cost up to £600 to make, but yet cost less than similar bodies from overseas.

A small woodworking section, besides making the few wooden parts for the bus bodies, manufactures all the barrows, ranging from small platform and sack barrows to four-wheeled milk barrows used by the Administration at stations and depots. This section is well equipped with band and circular saws, &c.

One of the most important sections of the whole shop is the store where all materials and parts are kept. "Anything for the car" might well be the slogan of this section, for neatly stacked in piles on the floor, or boxed in pigeon holes some £60,000 worth of spares are available. At present sixty-five complete engines for rail trollies are waiting to be put into the chassis being built on the premises. Here, too, are springs which have been manufactured in the shop (Durban has the only other depot in the Union to make springs), glass, rolls of rubber composition, jacks, belting, nuts and bolts, paint, sheet metal, plywood, and parts and accessories of all kinds. Two galleries surmount the main store, and in these are kept mostly small parts and body materials. Large supplies of special hardwood and steel are stored in racks outside the building where there is also a parking space for vehicles awaiting repair or delivery.

Adjoining the main building is a compact office block, built on modern lines, with ample accommodation and plenty of light and fresh air. Nearby are the workmen's lunch and wash rooms, a model of their kind, for the men are provided with individual steel lockers in a clean and airy rest room, and a new type of fountain in the wash rooms.



FACING A CYLINDER HEAD BLOCK

BLACKSMITHS SHOP

Showers are another feature greatly appreciated. An efficient first-aid room and a bookstall add to the amenities of the depot.

The following details of the working, &c., of these road motor services in the last month may be of interest :—

	1940	1939
Vehicle miles	967,006	801,476
Trailer miles	273,447	163,979
Passengers conveyed	647,811	515,367
Goods conveyed (tons)	76,575	46,292
Cream conveyed (gals.)	298,407	210,311
Revenue	£69,471	£57,419
Expenditure	£67,924	£54,137
Revenue per vehicle mile (pence)	17·2	17·2
Expenditure per vehicle mile (pence)	16·9	16·2

Acknowledgments are extended to the publicity department of the South African Railways for the photographs furnished for this article, and to the general manager's transport department for particulars very kindly supplied.

The Design of Large High-Pressure Steel Valves*

By FRANK D. COTTERMAN AND R. E. FALLS†

THE accurate determination of the proper metal thickness and the working stresses in valve bodies and bonnets is, in general, an exceedingly difficult problem. Valves vary in shape from the relatively simple contours of the conventional gate type to the more complicated form of the globe valve with the stem set at an acute angle with the run. Loading conditions may be extremely complex; for a valve body may be subjected not only to stresses induced by the internal pressure and flange bolting, but also to loads produced by improperly supported connecting piping. These loads must be resisted by the valve without distortion sufficient to cause leakage and without inducing stresses high enough to cause ultimate failure. The problem becomes particularly complex when valves for high-temperature service are considered, because of the presence of creep and the changes which take place in the properties of the materials.

For the design of cylinders subjected to internal pressure the formulæ of Barlow, Lame, Clavarino, and Birnie are well known, but are theoretically correct only for cylinders. Where bends or outlets, such as exist in valve bodies or elbow shapes, are encountered, modifications of these formulæ may be used. Modified Barlow's formulæ, with 50 per cent. added to the thicknesses determined from them "to compensate for the shape of the fittings," have been used as the basis for the minimum body metal thicknesses specified for fittings in ASA B16e. These formulæ are as follows :—

For pipes having nominal diameters of from ¼in. to 5in.

$$P=\frac{2S}{D}(t-0\cdot065)-125.$$

For pipes of nominal diameters over 5in.

$$P=\frac{2S}{D}(t-0\cdot1),$$

in which

P = working pressure, pounds per square inch.
t = thickness of wall of pipe, inches.
D = actual outside diameter of pipe, inches.
S = 7000 lb. per square inch.

The above formulæ are based on the use of carbon or carbon-molybdenum steels and a working pressure equal to the nominal or primary service pressure at the temperature rating specified in the standards. Pressure ratings for other temperatures have also been established by increasing or decreasing the working pressures in proportion to the working stresses permitted at the various temperatures.

With the substitution of the proper shape compensation factor and the proper working stress for other materials, these modified Barlow's formulæ may be employed to determine the metal thickness in a valve body. Variations in the calculated thickness must, of course, be made to provide ample

* *Journal* of the American Society of Naval Engineers.

† Research Engineers, Crane Co., Research and Development Laboratories, Chicago, Illinois.

fillets, to allow for possible corrosion or oxidation at high temperatures, and to produce sound castings as dictated by foundry requirements.

Safe working stresses for a given material depend upon its physical characteristics at the operating temperature, which is only slightly less than that of the fluid in a well-insulated valve. Recently, Table P-9 in the ASME Power Boiler Code has been revised to include the maximum allowable working stresses for various ferrous materials for metal temperatures from —10 deg. to 1000 deg. Fah. Fig. 1 portrays in graphical form the values given for the carbon and carbon-molybdenum steels commonly used for valves, flanges, and flanged fittings. Below temperatures of 650 deg. Fah. for carbon steel and 800 deg. Fah. for carbon-molybdenum steel, the allowable working stresses shown in Fig. 1 are

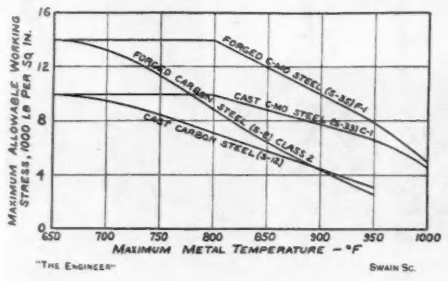


FIG. 1—*ASME Power Boiler Code Specifications (Table P-9, Revised August 18th, 1939) for Allowable Working Stresses*

equivalent to one-fifth of the nominal tensile strength for forged materials and one-seventh for cast materials. Above these temperatures the values are based on available creep data and general experience. Values for high-temperature service for other alloys, which are not included in this table, are based upon similar considerations of their individual characteristics.

In order to determine whether or not a design is safe, the internal hydrostatic pressure at which the proportional limit of the valve material is reached may be determined by a test at room temperature, in which a series of simultaneous observations of internal hydrostatic pressure and deflection are made. This method is applicable only to materials which have a definite proportional limit. Valves made of cast iron, for example, are generally subjected to bursting pressure tests to determine their ultimate strengths. Tests to destruction, however, are not generally applicable to steel valves, because of the difficulty experienced in holding flanged joints tight at high pressure, and the fact that, in a ductile material, yielding of the material under high stresses may mask the true location of the maximum stress.

The procedure for determining the proportional limit under internal hydrostatic pressure may be illustrated by tests conducted on a 6in. 600 lb. Navy globe valve of improved design. The end ports of the valve were blanked off with blind flanges, one of which was tapped to admit pressure. Deflectometers and strain gauges of 2in. span, equipped with 0·001in. or 0·0001in. dial indicators, were mounted at eighteen strategic positions on the valve body, as shown in Fig. 2. The location of these points was determined primarily on the basis of experience, since lime, Portland cement, plaster of Paris, and similar "brittle" coatings have not proved very satisfactory for locating the maximum stress in such structures, because of the large deflections necessary to produce flaking or cracking of the coating.

In conducting the test, the pressure was increased to a maximum of 4600 lb. per square inch, and deflections were read and plotted at each 200 lb. per square inch increment. The test was discontinued at this pressure, since it was obvious that the proportional limit had been exceeded.

The pressure was then released and the permanent set shown by some of the dials was determined. This method has been found to give more reliable results, for the small magnitude of deflections encountered, than that of reducing the pressure to zero and recording the permanent set after each increment of pressure has been applied.

Fig. 3 shows the data obtained from several representative dials. The lowest proportional limit, as determined by the point at which the linear relationship between pressure and deflection ceased to exist, evidently occurred at 3100 lb. per square inch hydrostatic pressure in the crotch of one of the elbow-shaped portions of the valve (Dial 18).

To obtain the safe working pressure, Paragraph A 30 (revised August 18th, 1939) of the ASME Power Boiler Code recommends the use of the formula

$$P = H\,S/E,$$

in which

P = maximum allowable working pressure, pounds per square inch.
H = hydrostatic pressure at the proportional limit of the pressure part, pounds per square inch.
S = safe working stress permitted for the material at the maximum operating temperature.
E = average proportional limit of the material, pounds per square inch.

The logic upon which this formula is based will be apparent if it is rewritten in the form $\frac{P}{H} = \frac{S}{E}$. The left side of this equation then represents the ratio of the allowable working pressure to the pressure at the proportional limit for the valve, while the right side represents the ratio of allowable working stress to the stress at the proportional limit for the material from which the valve is constructed.

The average proportional limit of the material may be obtained from tensile tests conducted on a number of coupons machined from the valve after completing the hydrostatic pressure test, provided that such bars are cut from a section in which the proportional limit has not already been exceeded. Results obtained from five bars cut from various sections of the body of the valve tested gave an average proportional limit of 46,000 lb. per square inch for the cast carbon-molybdenum steel (Grade C-1) from which the body was made.

Since the valve tested was designed for 850 deg. Fah. steam service, it can be assumed by reference to Fig. 1 that the maximum allowable working stress is 8800 lb. per square inch, which corresponds to a metal temperature of 850 deg. Fah.

Substitution of this value, along with those previously determined for H and E, into the ASME Code formula, gives

$$P = \frac{H\,S}{E} = \frac{3100 \times 8800}{46{,}000} = 593 \text{ lb. per square inch}$$

safe working pressure.

When it is considered that the actual operating temperature of the metal will probably be somewhat less than the 850 deg. Fah. rated steam temperature, and that the rate of loading the tensile bars to find the proportional limit of the material was considerably greater than that used during the hydrostatic pressure test of the valve body, it is evident that the calculated 593 lb. per square inch safe working pressure may be increased slightly. The valve may therefore be rated safely for 600 lb. per square inch working pressure at 850 deg. Fah.

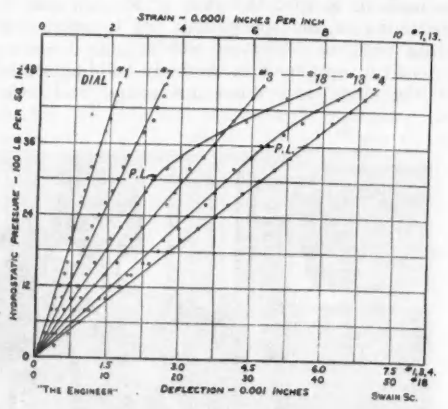


FIG. 3—*Pressure-Deflection Curves from Hydrostatic Pressure Test on 6in., 600 lb. Steel Globe Valve of Improved Design. (Figures at end of each abscissa scale refer to dial numbers)*

Conclusion

In this discussion it has been shown that the method of determining the metal thicknesses and the safe pressure-temperature rating for steel valves is not an exact process. However, the procedure described has been found to be satisfactory over a period of years, and it will probably continue to be used until sufficient research is performed to give a rational or more exact method of design.

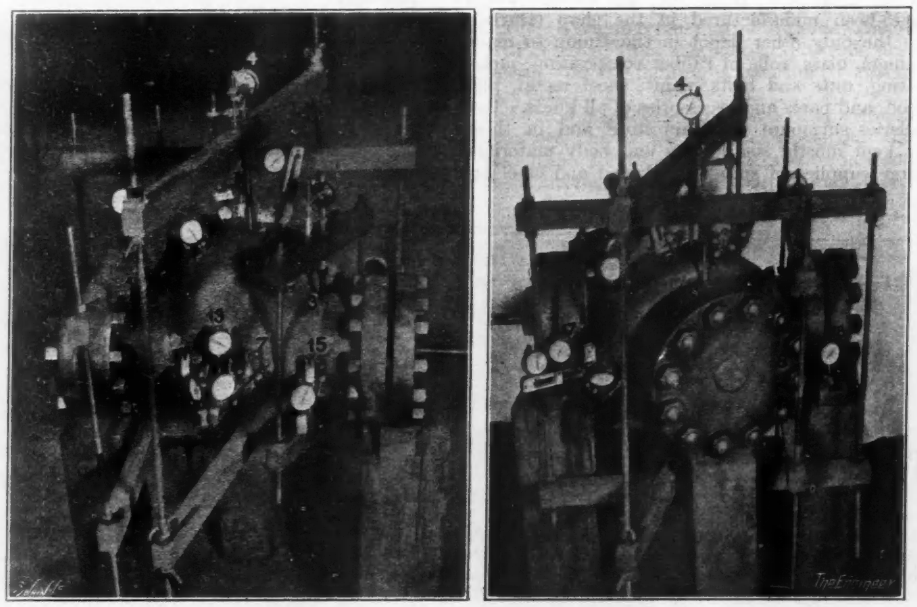


FIG. 2—*Placing of Dials for Hydrostatic Pressure Test*

The Size of an Aircraft Landing Field*

By K. N. E. BRADFIELD, D.Phil. (Oxford), B.Sc., &c.

How large should the landing field be? This question has been asked many times in the past, and it faces everyone connected with aviation to-day. From time to time people have answered it, giving dimensions for various classes of landing fields. History, however, shows that these classifications lasted only two or three years, and then the dimensions of the field in each classification were enlarged.

For example, in England the Air Ministry, in a publication of 1929, proposed that the dimensions of an airport to be used by the larger types of aircraft should not be less than 1800ft. in all directions, and should, if possible, be 2400ft. to 3000ft.

This remained unchanged until 1937, when the Air Ministry graded landing fields into five classes according to their size. The first class called for a landing strip of 2400ft. in length and 600ft. in width for all directions of wind. Corresponding figures for a second-class airport were 2100ft. and 600ft.

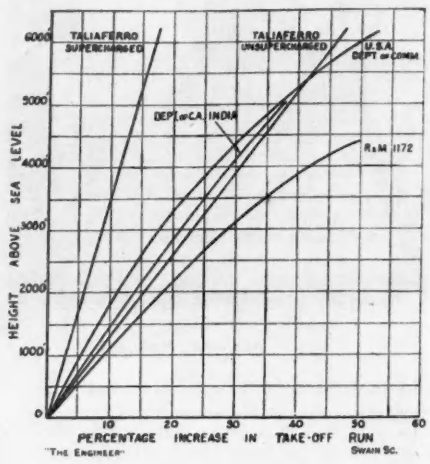


FIG. 1—*The Effect of Altitude on Take-off Run*

Barely a year later the minimum requirements of a "standard airport" were raised to 3000ft. by 600ft. for ordinary landing strips, and 3900ft. by 1200ft. in one direction for landings in low visibility.

Then, in 1939, the City of London airport, which is to replace Croydon, was designed with landing strips from 4500ft. to 6000ft. in length. Similar increases took place in the United States of America

* The Institution of Engineers, Australia. Excerpt from a paper entitled "Airport Landing Fields."

and Australia. The minimum dimensions required to-day for various classes of airports are given in the table.

The United States classification also specifies that the four landing strips must be so located that an aircraft will not need to land more than 22½ deg. out of wind on more than 10 per cent. of the occasions that the wind is stronger than 5 m.p.h.

The requirements for length given in the table are for landing fields at sea level, and the lengths must be increased according to the altitude of the landing field. Corrections for altitude proposed by various authorities are given in Fig. 1.

It should be noted that the figures of the table are for minimum requirements for each classification.

Minimum Dimensions Required for Various Classes of Airports. Dimensions are for Airports at Sea Level and in Normal Situations, where Winds Greater than 5 m.p.h. Occur from all Points of the Compass

	Australia, 1940.	Great Britain, 1938.	United States of America, 1939.
	Minimum dimensions.	Minimum dimensions.	Proposed minimum dimensions.
First class... ...	"Run" in one direction 4500ft. In all other directions 3000ft. Minimum angle of approach 1 in 30	One landing strip 3900ft. long and 1200ft. wide. Three others 3000ft. long and 600ft. wide. Minimum angle of approach 1 in 15	Four landing strips, each 4500ft. long and 500ft. wide. Minimum angle of approach 1 in 20
Second class ...	"Run" in one direction 3600ft. In all other directions 2400ft. Minimum angle of approach 1 in 20	Landing strips 2400ft. long and 600ft. wide for all wind directions. Mininum angle of approach 1 in 15	Four landing strips, each 3500ft. long and 500ft. wide. Minimum angle of approach 1 in 20
Third class ...	"Run" in one direction 2400ft. In all other directions 1800ft. Minimum angle of approach 1 in 15	Landing strips 2100ft. long and 600ft. wide for all wind directions. Minimum angle of approach 1 in 15	Four landing strips, each 2500ft. long and 500ft. wide. Minimum angle of approach 1 in 20
Fourth class ...	"Run" in one direction 1800ft. In all other directions 1320ft. Minimum angle of approach 1 in 15	Landing strips 1800ft. long and 600ft. wide for all wind directions. Minimum angle of approach 1 in 15	Four landing strips, each 1500ft. long and 300ft. wide. Minimum angle of approach 1 in 20

A number of airports such as those serving the cities of London, Paris, Berlin, Milan, New York, and Washington have runways constructed or proposed up to and even above 6000ft. in length. But these are comparatively few, and it is not thought by the author that the minimum length of landing strips in the classification of a first-class commercial airport will be increased above 4500ft. The difficulty of obtaining sites of these dimensions near towns or cities in the more densely populated parts of Europe and America prohibits them, and aircraft manufacturers will be forced to adopt such designs as will suit the airport requirements of the majority.

The reason for these increases in the length required for landing strips and consequently in the areas of landing fields is usually attributed to the development of the aeroplane. Higher speeds and more efficient performances have called for higher and higher wing loadings. In 1926 the wing loading of commercial aircraft was in the region of 10 lb. per square foot. It has reached three times that figure to-day and higher wing loadings are under consideration.

Actually, however, the design requirements for landing and taking off have not changed materially in the past ten years. For example, in 1929 an aircraft, before being approved by the United States Bureau of Commerce, had to demonstrate its ability to leave the ground with its maximum load in 1000ft. in still air at sea level. After eleven years this requirement remains unchanged.

Undoubtedly the increase in wing loading is one reason why airports are larger to-day than yesterday; but it is not the only reason. The public has demanded, and justly so, a greater margin of safety. People must be attracted to a new form of transport, and the greatest obstacle in the path of air transport is fear. It is nothing unusual—it was present in the early days of railways and automobiles. Just as the railway authorities install block signalling systems and the automobile operators build clover-leaf crossings, so the followers of air transport must install safety devices to make it not 99 per cent., but 100 per cent. safe—and one of the greatest aids to safety is an aerodrome adequate in size and adequately equipped for all emergencies.

One of the emergencies which must be provided against is the cutting out of an engine shortly after the take-off of the aircraft. This is, perhaps, the main cause of accidents in commercial aviation, and, fortunately, technical development in recent years has enormously decreased its chance of occurring. The employment of multi-engined aircraft for air transport is almost universal to-day, and, except in the case of very large aircraft, the twin-engined machine is preferred. Design requirements are such that this type of machine must be capable of maintaining level flight with only one engine. It can only do so, however, if the speed of flight is close to that which requires minimum power, and this speed is somewhat greater than the lowest possible speed of take-off. Considerably more power is required to drive the aircraft at the lower speed than at this optimum speed.

Thus, if a twin-engined aircraft has taken off at the lowest possible speed (about 70–80 m.p.h. for modern transport machines) and one of the engines fails, it has not enough power with the remaining engine to maintain level flight. If it is sufficiently clear of the ground, it can gain the extra speed required—about 30 m.p.h.—by diving. But if not it must land, and the field should be of such a length to allow this to be done safely.

This condition of safety has led the Civil Aeronautics Authority of the United States of America to suggest the following requirements. The first is that "for a multi-engined aeroplane to be operated with complete safety from any airport, the airport dimensions should be such that if one engine is suddenly cut when just half the length of the runway has been travelled (whether the machine is still on the ground or well in the air above the runway), it should be possible to continue the flight safely in a straight line with the remaining engine and to maintain a flight path which will clear all the obstacles which lie ahead." The other, somewhat simpler, stipulates that the runway length should be such that the aeroplane can be brought up to the speed required for flight with one engine dead, and then, assuming an engine to fail just at that point and the decision then be taken to abandon the flight, can be brought to a stop with the brakes without overrunning the end of the runway.

On this basis, and following an extensive series of practical tests, the Civil Aeronautics Authority has arrived at the proposed minimum requirements for various classes of airports, given in the table. The minimum lengths of landing strips given in this table may seem extraordinarily high when it is remembered that the take-off requirement for an

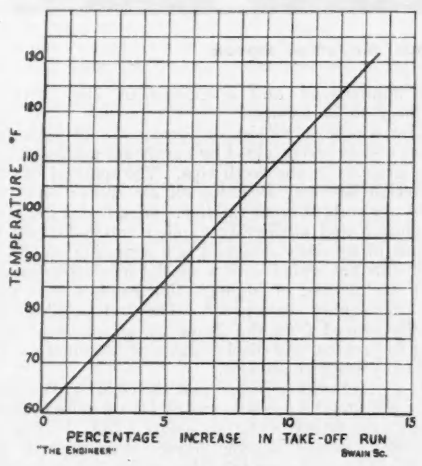


FIG. 2—*The Effect of Temperature on Take-off Run (Assuming Constant Propeller Thrust)*

aircraft is 1000ft. In practice, this length of 1000ft. is usually exceeded, since the take-off may be influenced by such factors as:

Variation in temperature, pressure, and other atmospheric conditions.

Bad surface conditions which may exist in wet weather.

Deterioration of condition during the service life of the aircraft causing its performance to fall off.

Imperfections in piloting technique.

Such factors may easily cause the length of take-off to be increased by as much as 40 per cent.

Working at the same time, but entirely independently of the Civil Aeronautics Authority of the United States of America, the Australian Department of Civil Aviation approached this problem of required lengths of runways from a very similar angle and obtained very similar results. The Australian requirement is that an aircraft should be able to come to the speed required for level flight with full power, and then, should that power fail, come to rest safely. As previously stated, the speed required for flight with full power is less than that required when one engine of a twin-engined machine is dead. The required length of runway is therefore slightly less when computed by the Australian method than by that used in America.

In such a subject as the length of take-off of an aircraft, where there are so many incalculable influences, any theoretical treatment can only be considered as an approximation. Theoretical calculations are useful, however, in indicating the order of the effect on the length of take-off run of different factors such as temperature and the roughness of the surface of the landing field.

Fig. 2 shows the effect of temperature based on a standard of 60 deg. Fah. assuming a constant propeller thrust. A sun temperature of 130 deg. Fah. increases the take-off by approximately 13 per cent. This is a most important consideration in the inland districts of Australia, where hot still air conditions often exist.

The effect of the roughness of the surface of the landing field is very considerable. The coefficient of rolling friction between aircraft tyres and a paved runway surface is approximately 0·02, and of an average grass surface 0·07. When the grass and ground are wet it would be greater, rising to 0·15 or more. From a theoretical calculation the two examples treated in Fig. 3 would need about 40 per

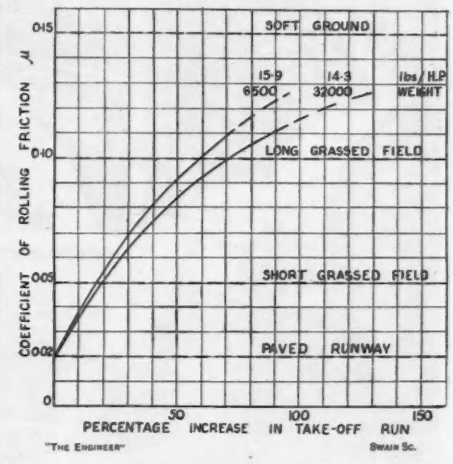


FIG. 3—*The Effect of Friction on Take-off Run*

cent. longer run to take off from an average grass field than from a paved runway. This agrees reasonably well with results obtained in practice.

There are, or course, many other factors besides the take-off which may influence the size of the landing field, but if it is large enough to satisfy that factor it should be large enough to satisfy the others. However, where conditions of fog or low visibility are likely to occur it may be advisable to construct at least one landing strip longer than those required for a safe take-off of a twin-engined machine when one engine fails. A suitable length of such a runway on a first-class airport would be of the order of 6000ft.

Every airport need not, of course, be of first-class dimensions, or even of second class. It need only be of adequate size to handle safely the aircraft which it expects or hopes to attract. Just as Sydney Harbour provides for craft requiring up to about 40ft. of channel depth, and Newcastle Harbour for 25ft., so one airport will provide for aircraft requiring a longer take-off run than others. In a system of airways, just as in a system of railways, there are needed main stations and junctions, express and local services, and larger and smaller landing fields. Every airport need not be large enough to accommodate a large high-speed, long-range type requiring a very long take-off run. In the United States of America, for example, such an aircraft might be used on a coast-to-coast run stopping only at New York, Chicago, and Los Angeles, while aircraft with lower performance characteristics and requiring a shorter take-off run would be used for passengers going to and from places between these cities.

In considering the dimensions of a landing field a most important consideration is the nature of the surrounding country.

A small landing field, with good unobstructed approaches and surrounded by open spaces such as playing fields and parks, is usually superior from the point of view of aircraft operations to a larger field enclosed by "built-up" areas in which obstructions exist. In this respect, also, it is to be noted that the isolated obstruction, such as the factory chimney or radio mast, is far more dangerous than the massive obstruction provided by a tall building or a gasometer.

TO REPLACE LEAD.—A product to be known as Philplug jointing material is being introduced to the electrical trade by the General Electric Company, Ltd., but it is also intended to replace lead in either ingot or fibrous forms for all classes of caulking and packing. It has been accepted by the War Office and Air Ministry for use in any type of spigot and socket joint for drainage and water mains.

All-Welded Electric Motor

By the courtesy of Bruce Peebles and Co., Ltd., Edinburgh, we are able to give some interesting details regarding the fabrication by electric arc welding of a slow-speed electric motor, one of a large number recently supplied and for which the company has now repeat orders in hand, for driving air compressors in various factories throughout the country.

Fig. 1 shows a general view of the motor, which is 16ft. long by 14ft. high and weighs approximately 40 tons. The machine is of the synchronous induction type, designed for a continuous output of 1900 B.H.P. at unity power factor and to operate on a three-phase, 50-cycle, 11,000-volt A.C. circuit, the speed being 250 r.p.m. Fabrication of the motor from steel plates with the aid of oxy-coal gas cutting and electric arc welding equipment resulted in important savings in cost of production, economy in materials, and shorter manufacturing time when compared with castings. Moreover, the method of construction adopted gave the added advantage of increased strength and rigidity.

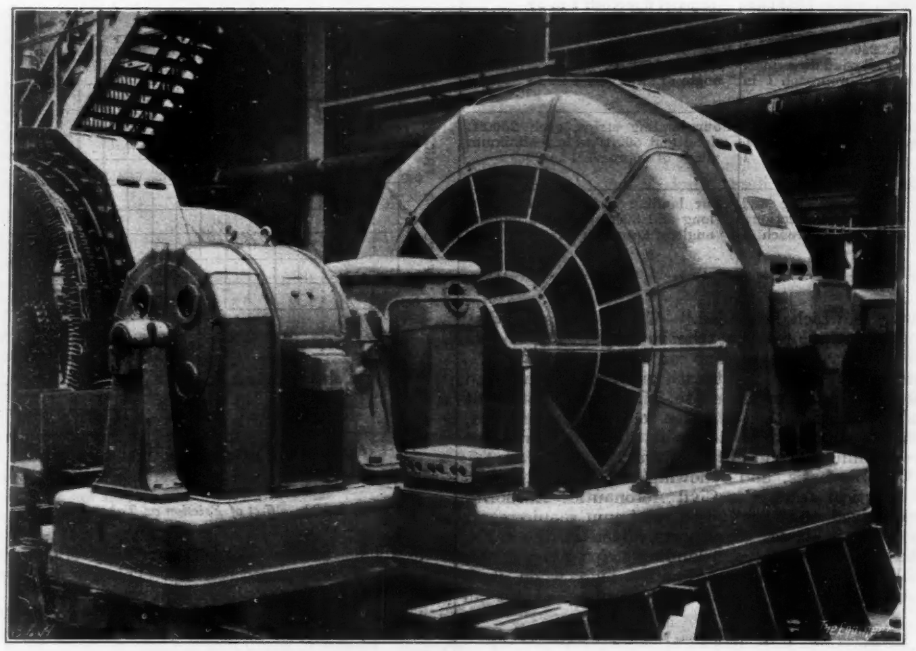


FIG. 1—1900 B.H.P. SYNCHRONOUS INDUCTION MOTOR

Generally speaking, the motor is similar in construction and appearance to an ordinary slip-ring induction motor, but it has a larger air gap to ensure synchronous stability and more rotor copper to reduce losses. The rotor is wound with three phases and the machine is provided with a direct coupled exciter for the purpose of supplying the exciting current to the rotor. The motor is self-ventilated. A powerful stream of air is drawn in by paddle type fans and air deflectors on the rotor, and propelled through the core ventilating ducts and over the windings, the heated air being expelled through openings in the stator frame. An air duct is provided in the bedplate between the exciter and the rotor slip-ring gear. Air trunks to the exciter and slip rings complete the circuit, so that the fan fitted to the exciter armature serves the dual purpose of drawing in cooling air to the exciter and propelling it along the air duct and through the rotor slip rings and brush gear. All the connections between the exciter and rotor are led through the air duct and the only external connections are those for the starter and the field rheostat.

The stator frame is built up from heavy section steel plate. It consists of two end pieces and a centre rib held together on the inner periphery by steel tie bars and on the outer periphery by a stout steel plate forming the outer surface of the frame. The feet are formed from steel bar and the whole structure is built to jigs and gauges to ensure accurate alignment and correct height of centres.

An interesting feature in the construction of the core, which incidentally is built up in the usual manner from insulated high-alloy steel, is the special teeth supports. The teeth at the ends of the core are rigidly supported by heavy section mild steel fingers extending over the whole depth of the core and well back on to the frame end plates. These fingers have adequate strength to transmit the pressure exerted by the clamps to the extreme edge of the teeth tips. Thus a uniform pressure is maintained throughout the core, and freedom from distortion, vibration of the laminations and spreading of the teeth is claimed to be ensured.

The windings consist of former-wound coils laid in open slots and retained by hornbeam wedges driven into grooves in the teeth tips. The method of construction adopted excludes all air spaces and provides for coils of great rigidity. Mica forms the main insulation and is directly applied and baked on by means of specially designed hot wrapping machines. The coils are sealed with a special insulating enamel and the method of impregnation ensures that they are thoroughly waterproof. The end windings are rigidly braced from the frame by an insulated steel ring to prevent any displacement or deformation due to heavy surge conditions.

It is of interest to record that the coils have successfully withstood a pressure test of 11,000 volts between turns and 66,000 volts to earth. Fig. 4 shows a partially wound stator frame and depicts the leatheroid troughs used for the mechanical protection of the coils in the slots, the steel fingers supporting the core teeth, hornbeam slot wedges and the bracing ring.

A view of the completed rotor is shown in Fig. 5. The hub is of cast steel. The spider is fabricated in two rings of steel plate stiffened by numerous cross stays at the outer periphery and by large area steel plates near the centre located in such a way as to form efficient air deflectors. Dovetail keys, for securing the core laminations, are welded into prepared slots round the outer periphery, a jig being used to secure accurate location. Fitted bolts securely hold the spider to the hub. The core is built up in the same way as the stator core. The rotor is bar wound, the slot insulation comprising mica moulded direct on to the conductors generally as in the case of the stator coils. Provision is made for shifting the stator sideways and Fig. 2 shows the stator racked clear of the rotor. Two motors undergoing works tests are shown in Fig. 3.

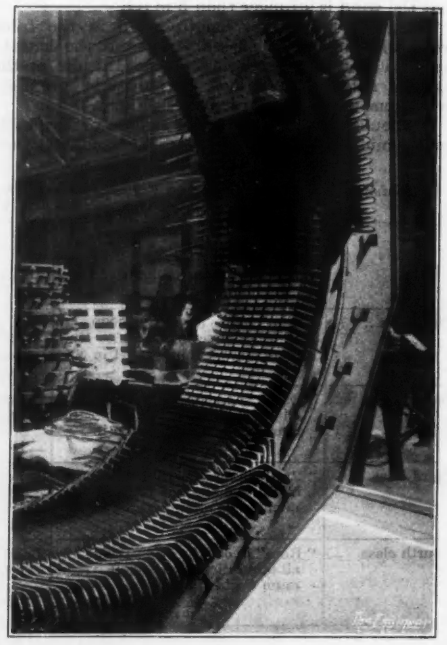


FIG. 4—PARTIALLY WOUND STATOR FRAME

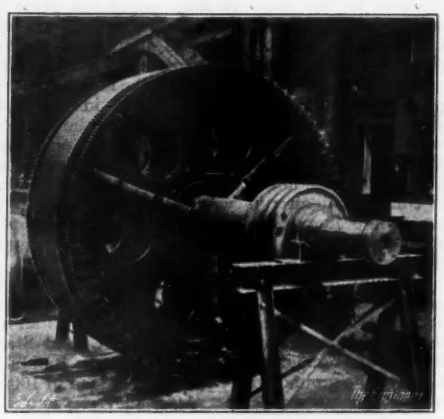


FIG. 5—COMPLETED ROTOR

The motor is self-synchronising. By means of a

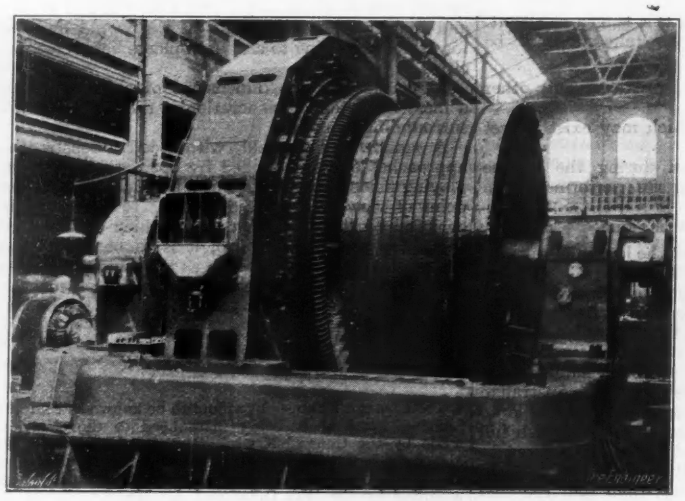


FIG. 2—STATOR RACKED CLEAR OF ROTOR

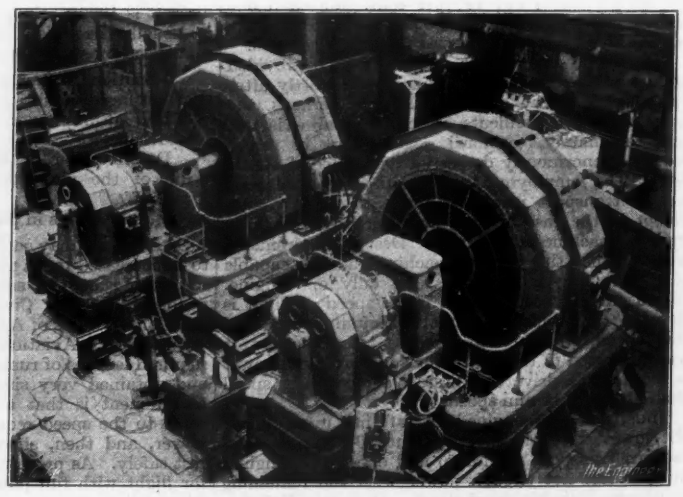


FIG. 3—MOTORS ON TEST BAY

liquid starter in the rotor circuit the machine is started up as an ordinary slip-ring induction motor, and as the speed increases the exciter, which is permanently connected to the rotor circuit and is self-exciting, builds up its field. The slip as an induction motor is small, and when the speed of the motor approaches full speed the rotor pulls into synchronism automatically. The machine then operates as a synchronous motor and the power factor is adjusted to that for which the motor is designed.

In conclusion it should be mentioned that the synchronous induction type of motor was adopted in preference to the salient-pole synchronous motor, as the operating conditions required certain flexibility as regards speed control. The machines have to operate for certain periods of time at speeds from 250 r.p.m. down to 50 r.p.m., under which conditions a high power factor must be maintained, and as it is a feature of the synchronous induction motor that it can be operated as a plain induction motor at speeds below synchronous speed, it was obviously the type best suited for the special operating conditions.

South African Engineering Notes

(By our South African Correspondent)

CAPE TOWN, September 9th, 1940.

Progress of Electricity in South Africa

DURING the year 1939 the demand for electricity in the Union of South Africa continued to grow larger, showing a percentage increase, taking all the undertakings in the country, of over 20 per cent. The Electricity Supply Commission was, of course, the largest supplier of current, its sales rising from 2,985,452,589 units in 1938 to 3,573,696,440 units in 1939. The revenue was £2,630,473, which exceeded production costs by £4771. During the year the aggregate generating capacity of the six large power stations of the Commission was increased by 171,196 kW, bringing the total capacity installed or on order at December 31st to 954,156 kW. The stations of the Commission consumed 3,028,767 tons of coal, costing £752,707, and railage on coal amounted to £257,002. Bulk supplies to mines, &c., represented over 2,780,000,000 units; the supplying of the 1232 miles of electrified single railway track required nearly 362,000,000 units, and sales to certain municipalities over 270,000,000 units.

The sales for domestic and street lighting uses increased from 10,520,028 units in 1938 to 13,990,173 units, and the annual consumption per consumer increased from 1484 units to 1598 units, which is regarded as satisfactory. An increase of over 33 per cent. in the total of units sold for domestic purposes by the Cape Town undertaking is also noteworthy. The Commission's loan capital now stands at £18,250,000, a loan of £2,000,000 at 3¼ per cent. having been successfully floated during 1939. Expenditure on capital account during the year was £1,174,054, bringing the total capital expenditure at the end of 1939 to £18,322,538. Expenditure on works under construction and extensions will bring the total expenditure to approximately £23,000,000.

Progress is reported on the Commission's rural electrification schemes, but further development in this direction may be retarded by the war. There have been considerable extensions to the Commission's systems, notably on the South Coast of Natal and in the Cape Western Province, which latter area may now be regarded as the most intensively electrified rural area in South Africa. On January 1st the Commission acquired by purchase the electricity undertaking of the Caledon Municipality. It is also extending its transmission system to supply the village of Darling. At the Epping Garden Village—a sub-economic housing scheme—390 houses were given a supply of electricity by the Commission. Every house is to be wired for an electric range and a large number of occupants have already installed a variety of domestic electrical appliances.

The two largest increases in consumption were for bulk supply for mining, &c., which rose from 2,290,455,578 units in 1938 to 2,780,418,879 in 1939, and railway traction, which rose from 308,884,273 units in 1938 to 361,905,545 units in 1939. The total consumption of electricity on the Witwatersrand by the gold mining and other industries and municipalities, &c., exceeded 4,872,000,000 units in 1939; and approximately 63 per cent. was supplied from the Commission's power stations at Klip and Witbank, the balance being supplied from power stations owned by the Victoria Falls and Transvaal Power Company, Ltd., three mining companies, and the Johannesburg Municipality.

The Klip generating station undertaking of the Commission has been brought into full commission, the last of the twelve 33,000-kW generating sets starting early in 1940. This station, as also the Witbank undertaking, is owned by the Commission, but is operated by Victoria Falls and Transvaal Power Company, Ltd. A further power station, the Vaal generating station undertaking, is at present under construction. It is to have an initial capacity of 108,000 kW. There is a possibility that the delivery of the plant will be delayed by war conditions. Progress has been satisfactory on the construction of the circulating water system, including the two hyperbolic cooling towers, each 320ft. high, coal appliances, and railway sidings. Water will be drawn from the Vaal River under agreement with the Rand Water Board.

Industrial Development

Activity in the development of industries and industrial production in South Africa is increasing steadily, and is being stimulated by the special requirements of the Union's war effort, and the fact that not only is Dr. H. J. van der Bijl the Director of War Supplies, but he is also Chairman of the Electricity Supply Commission and Chairman of the Iscor Steel Works at Pretoria. He is now supervising an addition to that works, which will increase its production from a little over 300,000 tons to about 440,000 tons, and the erection of an entirely new steel works with an output of 266,000 tons, which will give the Union a total steel output of well over 700,000 tons per annum. Dr. van der Bijl has a record for getting things done, and as an example of this, there can be quoted a great building that in peace time would have taken eighteen months, but which the Director-General had finished in three months. Many factories have been working at pressure for months; others have not been called on to help, but now a system is being evolved whereby every factory that produces certain commodities is being called on to make its contribution.

On the other hand, the value of building plans passed at the larger centres during the last four months amounted to only £4,208,714, compared with £6,239,295 during the same period of 1939, and some recession in activity is evident in factories engaged in producing clothing and footwear for civilian's requirements. Most of this is, however, being made up by requirements for the Army, and the demand is increasing. Engineering trades are, of course, very busy, especially the marine section.

The war has brought increased demand for the productions of Natal's chief industries, and it is confidently asserted that they are capable of far greater efforts yet. More than 595,500 tons of sugar were manufactured this season—an increase of more than 72,000 tons over the previous year, and constituting a great record. Of wattle bark there was an output of 97,932 tons and 41,236 tons of wattle extract, compared with 64,257 and 27,300 tons respectively in the previous year. The market for whale oil has improved, also the price. Natal land-operated whaling stations produced 5796 tons of whale oil, 2838 tons of sperm oil, and 4301 tons of fertilisers. From two whaling expeditions 15,990 tons of whale oil and 549 tons of sperm oil were obtained. Natal coal exported has, however, decreased from 70,000 tons a month to 55,000 tons, due to Germany overrunning the Low Countries and France.

In steel foundries and engineering and other workshops all over the Union, works are to-day turning out munitions and equipment, overseas sources having dried up suddenly, and many lines are being manufactured never previously attempted, and some of these lines are such an advance towards industrial self-sufficiency that they are likely to outlast the war. One great steel construction organisation is turning out the Giant Bellman hangars for aeroplanes, ready for quick erection. An output of several hundreds yearly is aimed at. Portable bridges for engineers are being made of high tensile steel with twice the tensile strength of ordinary steel. This is one of the materials never before produced in South Africa, but now made at one of the Union's steel works. Many of the armoured cars, of which the engines and chassis are imported and assembled in South Africa, are already being put into service. A production of hundreds a month is being reached, with armour plating of special steel, revolving turrets, and asbestos lining against the heat; bullet-resisting tyres are also being made locally. S.A. steel works turn out the rolled billets of steel which are used in making the standard gun adopted by the South African Artillery. Infantry mortars are being made in this country in many hundreds. The whole production in one workshop is now mortar sights. There were no jigs obtainable, so the workmen made them. Screws of a certain size could not be got, so larger ones were reduced to size. The shop was short of a vertical milling machine; it converted a drill to the purpose. Mortar bombs and aerial bombs are made in other workshops. Finally, it may be mentioned that there are now twelve Government factories making munitions, including explosives. The explosives industry, already one of the biggest in the world, has been further expanded to meet the requirements.

Rapid Construction at "Iscor" Works

A new large steel plant has been erected at the Pretoria Iron and Steel Works in about six weeks. Instructions were given that a large extension to the steel-making plant had to be made, and erected in record time on a prepared site. On June 6th this year the blue prints were completed, and a non-stop twenty-four hours a day effort began. Iscor steel was used wherever possible. The new building comprises thirty-six columns, each weighing about 4¼ tons, as well as many heavy eave girders and twenty-four crane girders, also weighing 4½ tons each, for provision had to be made for a 10-ton crane. Each of the seventy-two roof trusses weighed 3 tons. By June 20th great progress had been made. Floodlights had been provided so that work could proceed by night as well as by day.

While the steel skeleton was going up, interior work on the new plant was in progress. Great annealing furnaces, bogies, gas furnaces, quenchers, and preheaters with their platforms and other mechanical details were being produced in the Iscor plant and installed before even the roof was ready to cover them. In the third week in July the first furnace was in operation, and was followed quickly by a second. Very soon the whole plant will be in operation.

The main building is 60ft. high, 65ft. wide and 425ft. long. The foundations called for the removal of 8000 cubic feet of soil. This was accomplished with three motor trucks, as no rail tracks were available. No mechanical digger was used. There were 6000 square yards of wood shuttering or "forming" for the concrete, of which 4000 cubic yards were used, and 60 tons of reinforcing steel were required. Work went on right around the clock, and 80 per cent. of it was completed in five weeks' time. The foundations involved column bases, stack foundations, and furnace foundations, flues, quenching pits, warming pits, cooling towers, and electric furnace plant pit; 650,000 standard size bricks were used, totalling 2600 tons of bricks. An extension of the building east is now in progress, and the staff is standing by waiting for orders for another similar plant to be erected at such time as the management decides upon proceeding with the work. It may be noted that after the templates—full-size patterns cut out of wood—were all prepared they were fitted together to make sure that everything fitted perfectly; a steel member made from a template and not fitting or rivet holes that did not match up would certainly kill all speed.

South Africa Exporting Iron Ore

South Africa is at last an iron ore exporting country. Iron ore is the latest addition to the steadily growing list of commodities exported from the Union to all parts of the world. About 17,000 tons have already been shipped. The export of ore is expected to build up an extensive trade. In view of the large quantities of high-grade ore in the Union this latest development of the country's resources is of considerable importance, especially to countries that have been cut off from their previous suppliers as the result of these having been overrun by Germany. The ore which is now being shipped from Durban comes from the Northern Transvaal. It has been described by Dr. J. H. van der Bijl, general manager of the Iscor Steel Works of the S.A. Iron and Steel Industrial Corporation, situated at Pretoria, and also Director-General of War Supplies, as being a remarkably pure hematite containing up to 68 per cent. metallic iron. The quantity of ore known to contain about 68 per cent. of metallic iron is just over 120,000,000 tons, but no doubt this would be vastly exceeded if the enormous deposits of iron ore in the Union were examined carefully. As to ore running 50 to 60 per cent., the quantity is known to be very large, while of ore of a percentage from 45 to 50, the quantities are estimated to be of the order of thousands of millions of tons. Much of these deposits are in close proximity to high-grade manganese and inexhaustible supplies of good quality coal. All can be cheaply mined and the railway rates to ports for shipment are moderate. High-class ores of vanadium are mined in Northern Rhodesia and chrome ore is found in large quantities in the Union, carrying a percentage of around 50 per cent., and with enormous deposits of the best limestone and dolomite, the Union has at hand all the materials for the manufacture of steels of unsurpassed quality, no matter what special alloy may be required.

National Roads Progress

The mileage of national roads completed up to the end of 1939 in the Union of South Africa was 1786, and that under construction 296, exclusive of existing bituminous-surfaced roads still to be improved to national road standard, according to a report of the National Roads Board.

The mileage under construction includes only work that had reached the stage of completed formation and not hundreds of miles on which work of formation is still proceeding. There are 2082 miles open to traffic, but periodically sections are closed to permit the construction of the further stage. Of the 5400 miles of recommended national roads to be constructed at a total cost exceeding £23,000,000, a total of 3476 miles has been surveyed, of which 913 miles were completed during 1939, and, in addition, field work has been done on most of the balance. The number of bridges constructed since the inception of the scheme is 187, and 78 are under construction. Last year 106 bridges were completed and there are 52 more being constructed than at the same time the previous year. The progress on bituminous surfacing is not up to expectation, but lack of funds compelled the Board to request the provinces to slow down construction on this surfacing. Good progress was being made with bridge construction until the shortage of steel, due to war conditions, hampered it.

The Engineer

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THE DEFENCE AGAINST BOMBING AIRCRAFT

THESE many months of war have shed useful light on the highly debated and important question of how far defensive measures against all forms of air attack can meet any and every possible growth in the latter's intensity. As development proceeds, aircraft travel vastly further, and much faster, than they did, and they are, moreover, increasingly better armed. When the whole tempo is thus speeded up, can the defence, whether from the air or from the ground, keep pace? That is a vital question.

Both before and since the outbreak of war this question has been the subject of widespread discussion, though not always with that degree of knowledge which its complexity requires. For much is still hidden under the veil of very necessary secrecy. There has, for instance, been an easily understandable divergence between the military and scientific points of view. The latter has been optimistic as to what it may be possible to do by scientific means of defence, if vigorously explored; the former has adopted a more cautious attitude, showing the layman's fear lest the deductions of scientific men should prove unworkable. On the one hand, it has been suggested that in the years immediately antecedent to the war, the power of the defence was overtaking that of attack; that the attack might well prove to have reached its relative maximum potential in the years before the war, and thereafter to have shown some decline, and that this might be expected to continue. It was claimed by those who took this view that much more, vastly more, had been done to strengthen the defence than the public could know; and that some day the defence against aircraft might, it was hoped, become as effective as was that against the submarine. That, briefly, was the case for the defence. In support of the power of attack, it was urged that the offensive had gained in every way that could be definitely measured, such as in aircraft speeds and climbing ability; and that it was dangerous to encourage a belief that the power of defence was increasing over that of offence, since war might show the contrary to be the case. On these opposed views, the general public may well have thought that a difference of opinion on a matter so vital could not do otherwise than increase the uncertainties of the time, but the lessons of history were held by many to justify the belief that no war ever did, or ever would, justify all the expectations of the military expert. Hence, an alternative view was, at least, worthy of a hearing. Now after a year of war, how does the matter stand? There have been innumerable air raids on this country; London itself has had thousands of tons of high explosive bombs aimed at it, beside tens of thousands of incendiaries. The defence by the R.A.F. and by the A.A. ground defences has been truly magnificent, indeed heroic. Both of these defences will grow in strength in the coming months—as will also the ingenuity of the tactics employed. Without pretending, which would be absurd, that the time is ripe for any final judgment, it may be claimed that, so far, this most practical test gives not a little support to the optimism of the scientific point of view. Against daylight raiders, not only has anti-aircraft fire from land as well as from ships proved an immensely more effective defence than its many pre-war critics thought likely, but the relative fighting strength of invading bombers and defending fighters has been shown to be most emphatically on the side of the fighter, even when the former has the assistance of some of its own fighters; and this in far greater degree than many air enthusiasts had cared to suggest. The remarkable percentage of losses suffered by fleets of invading bombers coming in daylight against any really well-protected area has been gratifyingly large, substantially higher, in fact, than the ratio of 15 per cent. which competent authority has estimated to provide an adequate deterrent to the long continuation of such expensive raids.

We owe a great deal to the inventors and scientists who have made this possible, as well as to the pilots and gunners who have fought with such superlative gallantry. It encourages us to hope that by the energetic pursuance of such methods there will be discovered that effective addition to those found so useful in daylight hours which will defeat raiding by night. This problem is no simple one. In the absence of the light of the sun there is no radiation to which the eye is immediately sensitive. Sound waves, it is true, reach the ear as easily by night as by day, but the speed with which they come is slow, and the information they bring belated. Rays of sound do not travel in paths that can be predicted with all the accuracy we should like; for that to be possible, very full knowledge of wind and temperature distribution at all heights and distances would be needed. The use of infra-red radiation has often been suggested, but it is subject to severe absorption, and the eye is not directly sensitive to it. Something entirely new must be added, and here the British public relies on the ingenuity and inventiveness of its scientists and inventors. When science has added this to its other marvels, as we are bold to expect that it will, all will rejoice that at last a complete counter has been found to a deplorable misapplication of the great discovery of human flight.

Science and Warfare

IT is hard indeed to find a *raison d'être* for the new Scientific Advisory Committee appointed by the Government, of which the terms of reference and membership are recorded in our Journal to-day. The titular Chairman is Lord Hankey, Chancellor of the Duchy of Lancaster; he is not a scientist. The six members are Fellows of the Royal Society, with their President, Sir William Bragg, at their head. The others, with the exception of Dr. Appleton, Secretary of the Department of Scientific and Industrial Research, are specialists in biology, physiology, and medicine. This fact would have led us to suppose that the Committee was an *ad hoc* one for the study of some urgent biological subject, were it not for the wideness of the terms of reference. These terms are:—To advise the Lord President of the Council "on any scientific problem referred to them"; to advise Government Departments on the selection of individual scientists for special work; and to bring to the notice of the Lord President "promising new scientific or technical developments."

Without impugning the scientific attainments of the members of the Committee, we say without hesitation that they are not qualified to do any of these things outside their own "spheres of influence." Not one of them, not even Dr. Appleton, who is a physicist and an expert in radio-transmission, is, for example, fully in touch with the technological aspects of applied engineering and chemistry. They are all members of the Royal Society, and, as everyone knows, the Royal Society is devoted far more to the sublime altitudes of science than to its utilitarian applications. It is only necessary to observe how small is the number of engineers who have been admitted to membership of Burlington House to recognise that the Society's sympathies lie in another direction. In these circumstances we fail to see how the Committee can fulfil the functions covered by its terms of reference better than, or even as well as, the Advisory Council on Scientific Research and Technical Development, which has been in existence for many months and of which Sir William Bragg and Dr. Appleton are also members. Let us be quite candid, even at the risk of apparent disrespect for the most august scientific institution in the land. Let us tell the Government and the Lord President of the Council that they should recognise that the Royal Society is not the only scientific organisation in the country; that, in fact, there are others which, owing to their nature, are more likely to be of immediate value in the solution of urgent technical problems. There is little time in the middle of a war to develop new scientific principles. The process is slow and the need of haste is imperative. The call is for action rather than for prolonged and precise thinking. By all means let scientists continue to apply their highly trained minds to the burning problems of the day, but at the same time let every effort be made to enlist the help of all those, known or unknown, who are of a more technical turn of mind. That could be done by a clear statement of the problems from every possible aspect, and we suggest with the greatest seriousness that such statements should be at once prepared. Invention is hampered if every detail of a problem is not known; and the more widely the details *are* known the greater the possibility that the fruitful imagination of some inventor may be stirred.

The Government has made no real effort so far to mobilise the knowledge of practical men; there is not even a Ministry of Inventions. It has not appointed a Committee of Engineers, and it has taken no steps—to the best of our belief—to set before engineers as a body even those problems which they are peculiarly fitted to solve. Had such a body existed, it could certainly have given advice which would have avoided waste and extravagance, and might have been able to originate new inventions of a very desirable kind. Such a body, with terms of reference similar to those of the new Committee, should be set up without further delay, or, failing that, the new Committee should at least be strengthened by the inclusion of the secretaries of the leading engineering and chemical institutions. That would be a *pis aller* but at least it would satisfy the second term of reference—the nomination of individual experts but with technological rather than pure scientific qualifications, for the secretaries are in direct touch with such men amongst their members.

Obituary

SIR ROBERT HADFIELD

Sir Robert Hadfield was the hardest working man under the sun. He worked in his home, in his office, at the works, in the train, in the drawing room, at the club, in his car. There was never a moment when his busy mind was at rest. The interests of the splendid business which he had built up were ever with him. Had he not been a scientific metallurgist he would have been a bag-man of the first water. He had no diffidence about turning science to business account; he pursued Science with that object in view, and he compelled her to serve him. We can say this without any disrespect to his memory, for he was quite open about it. He was the scientist become business man, and he saw nothing to be ashamed of in it. He worked unremittingly to turn science to a useful account, and for that the public, no less than his company, has reason to be grateful to him. Science in the abstract is as great as Diana of the Ephesians, and as adorable; but it is applied science that benefits the material world; that gives it its bread and butter. No one will ever be able to calculate what Hadfield's two great metallurgical inventions, manganese steel and low-hysteresis steel, have done for mankind. They are certainly to be counted amongst the great metallurgical inventions of all time. But he was not content merely to discover or invent them. He built up a great industry for their exploitation, and thus added to the riches and welfare of his native city and of his native land. What if he did push his wares at all reasonable seasons; they were good wares, worth pushing, and if he had been less persistent in his efforts the benefits which he was in a position to confer would have been less widely distributed. Perhaps, after all, he only differed from others in being quite open in his devotion to business.

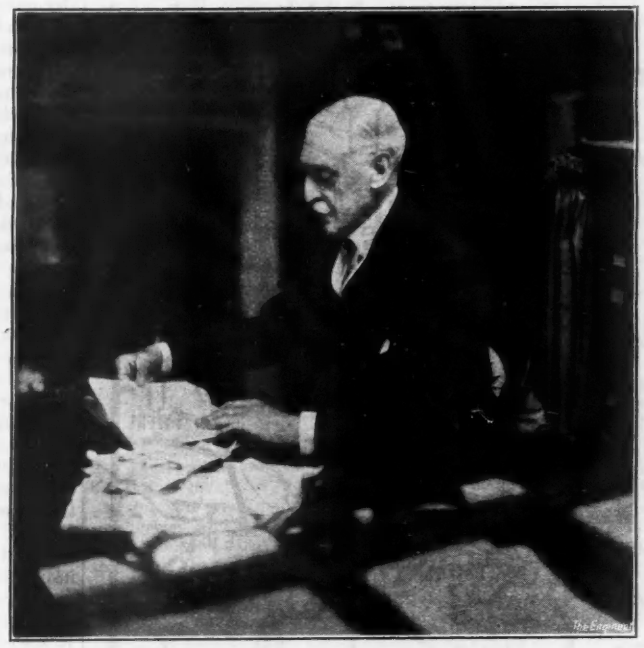
Sir Robert, who was born in Sheffield in 1859, and died on September 30th at the good round age of over four score years, inherited from his father a small steel works at Attercliffe. He was educated in the ordinary way at the Collegiate School, Sheffield, but he began his own education in a laboratory which his father, farseeing man, provided for him. There he pursued the studies which were to stand him in such good stead a few years later; but we must suppose that he learnt business from his father and in the Attercliffe works. At any rate, when he was still no more than thirty years of age, he became chairman and managing director when the concern was converted into a limited liability company. It was in this laboratory when he was still a youngster that he began his investigation into alloy steel, being directed thereto by a pamphlet describing the ferro-manganese alloys shown by the Terre Noire Company at Paris in 1878. He translated the whole of the pamphlet and was inspired by it to begin an investigation of his own, and in 1882, when he was only twenty-two years of age, he had not only made manganese steel, but had discovered how to heat-treat it to bring out its peculiar properties. On September 7th of that year, he wrote in his note book: "I was led to make the following experiments with a view to the production of a very hard steel for tramway wheels, and grinding wheels or discs to be used in the place of emery wheels." Continuing, he added: "The experiments have led to some very curious, perhaps most momentous, results that may to some extent revolutionise metallurgical opinions as regards alloys of iron and steel." That prediction was justified. Manganese steel, as all engineers know, has the two peculiar properties that it becomes tough instead of hard by quenching, and that despite the presence of nearly 90 per cent. of iron it is practically non-magnetic and a very poor conductor of heat or electricity.

It cannot be claimed for Sir Robert that he was the first to dabble with alloy steels, but he was certainly a leader amongst pioneers and a stout believer even at an early date in the future of such alloys. In 1892—he was still a young man—he said in a paper before the Iron and Steel Institute: "The special question of steel alloys or combinations will be eventually found to possess a considerable practical importance to the world at large, and perhaps to be the means of eventually enabling our civil and mechanical engineers to design and carry out works of a magnitude which, notwithstanding the great strides made during the last few years, even at present are not possible." That propheoy has been justified already in a hundred ways, and when at length metallurgists are able to co-ordinate the mass of observational data which is being continuously amassed alloys more remarkable still may be discovered.

Let us now turn to silicon steel. Silicon is one of those elements which is almost, but not quite, a metal. For example, whilst it behaves like a non-metal, it possesses some properties not unlike those of aluminium. "There is," as Sir Robert himself said a few years ago, "some hidden mystery here which, perhaps, X-ray examination will ultimately reveal to us." This remark occurs in "Metallurgy and its Influence on Modern Progress," which Chapman and Hall, Ltd., published for Sir Robert in 1925. In Chapter VIII of this comprehensive work the inventor told in detail the history of silicon steel. Here was an excellent example of a serendipitous discovery—a discovery made accidentally in the course of a search for something else. In 1882 young Hadfield observed that a pair of mill-pinions containing 1½ per cent. silicon had a grinding action on each other. He was at that time looking for something better than the emery wheels of that day which were apt to burst, and hoped it might be possible to make an abrasive alloy of steel. The first alloy to be tried contained 4 per cent. Si and 8 per cent. Mn. "On full examination, and after making tests, it was found that the alloy resulting from the combination of these two elements, manganese and silicon, some carbon and the rest iron, was of no advantage, and did not possess the qualities desired." Hadfield therefore determined to try the effect of manganese and silicon separately, and from this research it was that both manganese steel and silicon steel resulted. It appears that any thought of making a grinding wheel had, at this stage, been given up, and that the research was, in fact, "pure." But between 1884 and 1886 it had become clear that both steels had valuable properties and they were covered by patents.

Silicon steel was originally produced with a view only to improved physical properties in the cast or rolled form, and great quantities of it were employed for shipbuilding and other structural purposes. Much of it was used, for example, in the top-sides of the "Mauretania" and "Lusitania," where advantage was taken of its high-tensile strength. It was not till some years later, *circa* 1902, that the peculiar magnetic properties of the alloy began to be exploited, and years of patient research, experimentation, and development were called for before full success was achieved. In this work metallurgists and engineers all over the world have taken part, but to Hadfield belongs the honour of having in the first place convinced engineers that silicon was not the terrible bogey it had been held to be, but, in fact, when scientifically used, an angel in disguise.

Whilst Hadfield's name will always be remembered especially in association with the two alloys to which we have given so much space, it would be wrong to imagine that his interest began and ended with them. Far from it. There was no aspect of steel metallurgy to which he was not devoted, and the researches carried out by him or under his direction and inspiration ran into hundreds. Generally, they had a utilitarian objective, but the loving care which he gave to the analysis of a collection of alloys made by Faraday shows another aspect of his character. He recorded in 1925 that "during the past forty years or so, more than 3000 different steels have been made and tested under the author's supervision, and careful records of their properties and behaviour have been preserved." We need not remind engineers that in the early days steel castings left much to be desired. They were often porous or honeycombed, and were subject to other defects which occurred in the mould. Moreover, there was but little variation in qualities; a steel casting was a steel casting, and was not specially adapted to the purpose for which it might be required. If an exceptionally tough steel or an anti-corrodible steel were required it could not be obtained. The one quality was all that could be offered. Hadfield attacked this problem in his works. He not only brought about a great improvement in castings, but introduced a variety of steels to meet the special requirements of engineers. And besides industrial steels he took up with characteristic energy the production of armour-piercing projectiles, of which he made huge numbers of various calibres up to the largest during the war of 1914–18.



Sir Robert Hadfield, F.R.S.

There was never a metallurgist so decorated as Sir Robert. He was created a Knight in 1908 and a Baronet in 1917. In 1909 he was elected a Fellow of the Royal Society. He was an honorary Doctor of Science of Oxford and Leeds, a D.Met. of Sheffield, an honorary member of the leading learned societies, a Freeman of the cities of London and Sheffield. We do not know how many foreign societies had honoured him in one way or another, or on how many boards, committees, and commissions he served. The medals he received ran into dozens. The Iron and Steel Institute gave him the Bessemer, America awarded him the much-coveted John Fritz. France gave him three medals and made him a Commander of the Legion of Honour; Japan elected him to the order of the Sacred Treasure; Italy made him Commendatore of the Order of the Crown of Italy. Sweden, Norway, and Russia honoured him. There is no end to them. It is recorded that he read no less than 222 papers before various scientific and technical societies at home and overseas, and he was the author of two or three books, notably that already referred to, and another on "Faraday and his Metallurgical Researches," in which his examination of the Faraday alloys mentioned above may be found.

We have from time to time noted the fact that fifty years or so ago several of the industries of this country which are great to-day were being built up by quite young men. Allen and Yarrow are two good examples and many more might be named. Hadfield must

be included in the series. It is true that he did not found the business but its subsequent success was due to the combination of science with untiring enterprise which he displayed. Moreover he "made himself." No educational escalator helped him to the summit. He climbed by his own exertions. Perhaps, in these later and more scientifically sophisticated days that is no longer possible. It may be true that youth in 1940 has not the opportunity to go a-pioneering. We do not know. But we do know that too much honour cannot be paid to the young pioneers of the past and that it is good to be able to feel that, like Hadfield, many of them were men of our own blood.

Air Force Targets in Germany

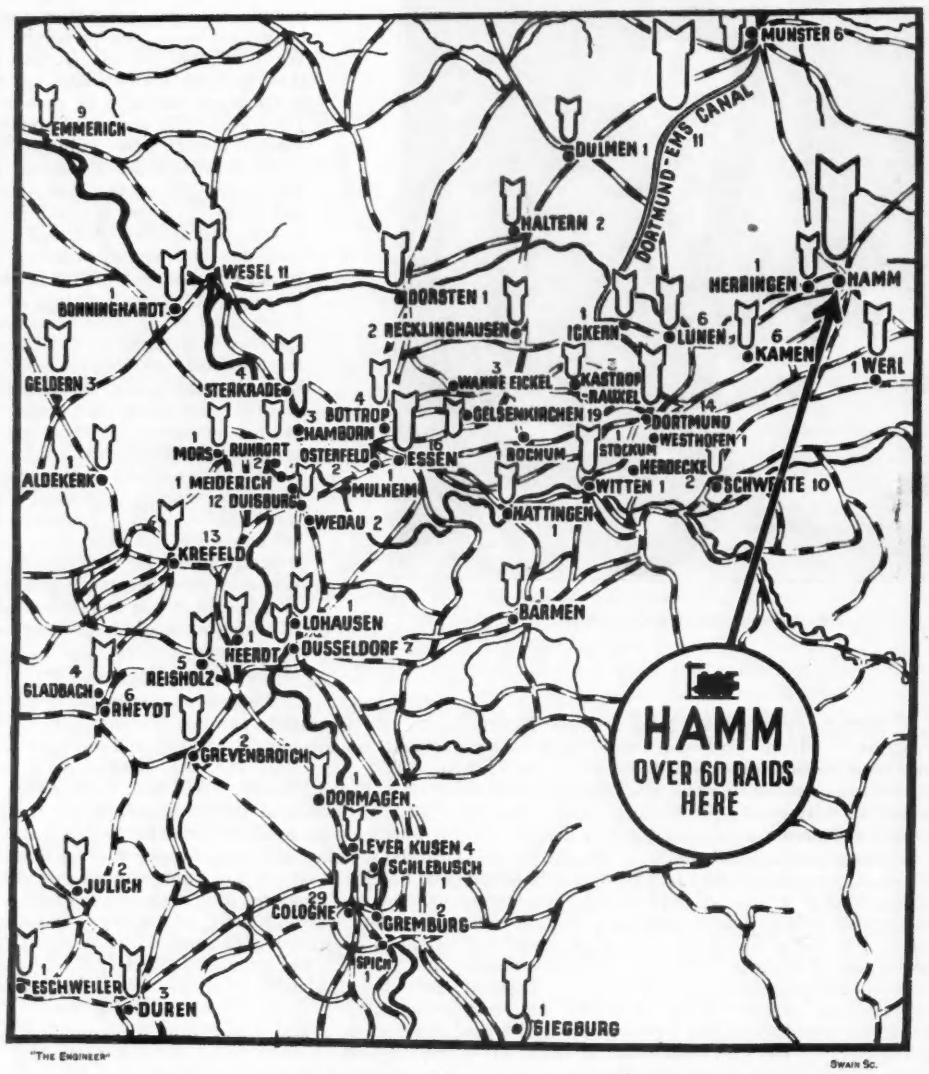
No. VI

(*Continued from page 199, September 27th*)

IN our previous five articles we have dealt with some of the more outstanding bombing attacks on Germany's ports, transport systems, and industrial undertakings, which form part of a well-considered and bravely executed plan of long-term interference with all that helps the German war machine and the supply of arms and munitions to its fighting forces. On July 12th we dealt with the attacks on Kiel and the Kiel Canal and the bombing of the German battleship "Scharnhorst," and in the same article described the railway marshalling yards at Hamm in the Ruhr, which have suffered the brunt of the British bombing attack, having been bombed no less than sixty times. In an article published in our issue of July 26th we dealt with the attacks on the Dortmund-Ems Canal, on which to date there have been no less than eleven attacks, and we illustrated the aqueduct over the River Ems and the stop gates erected for the protection of the canal system. In our third article—see our issue of August 9th—we described and illustrated by maps the ports of Emden and Wilhelmshaven, while on August 30th we dealt with the air attacks made by machines of the Bomber Command on the famous Junkers works at Dessau, where important sections of the works, including the power station, suffered damage. Our latest article, which was published on September 27th, was devoted to a description of the Berlin electricity supply network and in particular to the two large power stations of the Berlin Electricity Supply Company, the Klingenberg power station and the peak load station at Berlin West, which have been the subject of repeated attacks from the air by machines of the Bomber Command.

On Monday, October 7th, the Ministry of Information gave further particulars of the bombing attacks on Germany and German occupied territory, which have been carried out up to Monday last by the Royal Air Force. From the facts given in the statement and maps accompanying a detailed list of bombing attacks, it is possible to discern something of the careful plan which lies behind the attacks. In the accompanying map we show only the Ruhr district, with its closely set targets, and in a later article we hope to deal with the attacks on Germany as a whole and give a larger map showing the targets which have been bombed. The Ministry of Information statement shows that more than 700 blows have been struck at Germany itself, from the Baltic Sea to Switzerland, from the North Sea hundreds of miles inland to Berlin and beyond. The chief objectives have been oil depots and refineries, armament works, aerodromes, docks and naval bases, goods yards and railway junctions, and barges and shipping. Beside each name of a bombed target on the map is a figure showing the number of times it has been attacked. The map indicates that every town of importance in the Ruhr has been visited by the R.A.F. Hamm has had over sixty raids and Essen, the great arms centre, sixteen. Our raids are based on long-prepared plans of attack on targets of economic as well as immediate military importance. Every target selected has its place in the "master plan," even when its significance is not at first obvious. For example, although Germany has plenty of aluminium, we still bomb her aluminium plants, to stop Hitler using the metal as a substitute for the copper he badly needs. Weak spots in Nazi industry and transport are systematically sought out and attacked. Power plants, key factories and road and rail junctions all fall under the wings of the R.A.F. The bombing of barge concentrations at "invasion" ports not only removes the threat of a Nazi landing—it inflicts a severe handicap on Germany's use of an important and otherwise less vulnerable form of transport—inland waterways. For the barges have been brought from the Rhine and other German rivers which normally carry huge loads of her goods. Germany's synthetic oil industry, of great importance to her in war, is being systematically smashed. In the last two months her oil plants in Western Germany, which normally produce 40 per cent. of her total of 2,500,000 tons of oil a year, have been continuously and heavily attacked. Now the R.A.F. is beginning to turn its attention to Central Germany, where more than 50 per cent. of her total oil production is carried on. The mighty Leuna works have already been visited more than once. Attention has also been given to oil refining plants, most of which are concentrated in Hamburg, which has had thirty-six raids; Bremen, thirty-one raids; and Western Germany, including Hanover, which has suffered nineteen raids.

It is believed that Germany's aircraft production and her power to replace machines brought down in this country has already been reduced appreciably by our bombing attacks. Another primary object in our attack on Germany's industries is the disorganisation of her sea and land transport. Damage to the great docks at Hamburg and Bremen, for example, has prevented the loading and unloading of any ships there, and is seriously hindering Germany's seaborne trade in the only area still left open to her. Destruction at the principal ports places a further strain on the already overburdened German transport system. Internal water transport has always been of great importance to Germany, and has been used with even greater intensity since the outbreak of war to relieve the strain on the railways. But the R.A.F. is making sure that rail traffic is strained still more by heavy attacks on junctions and marshalling yards. The famous viaduct of the Dortmund-Ems Canal, already referred to, has been continuously under attack. It was the chief link for heavy transport between the Rhineland and North-Western and Central Germany, and was used to carry the equivalent of 400 trainloads daily. Such damage has been done to Germany's transport that her industries have often had their entire work interrupted. Export trade from other countries to Germany has been interfered with and all exports from South Denmark were stopped for three weeks at the end of June.



MAP SHOWING BOMBING ATTACKS ON THE RUHR DISTRICT

"Salvage" and the Social System

(*Contributed*)

AMONG the many changes due to wars people have always had to reckon with the addition of words to the vocabulary of the ordinary citizen as well as the giving of additional meanings to words in common use. Some of these changes in use fail to survive the war which has given them currency. In other cases the changed meaning comes into our daily speech, perhaps for a generation, perhaps for more than a generation. This, of course, is common to other social changes, such, for instance, as the virtual disappearance (in the daytime) of long skirts for ladies' wear and the general shortening of ladies' hair which were marked features of the war of twenty-five years ago.

The word "salvage" has hitherto been almost entirely confined to marine incidents in connection with disabled or wrecked ships. The Oxford English Dictionary under the word "salvage"

gives its primary meaning to a payment or composition for voluntary efforts in saving a ship and its cargo from impending peril or actual loss, and passes on to the secondary meaning of saving a ship or its cargo from wreck, capture, &c. There is a third meaning of property salved or saved. There is no indication that the word may be used in the sense implied by the appointment of a Controller of Salvage as a branch of the activities of the Ministry of Supply. It therefore appears that for the immediate future we are to apply the word "salvage" in the service of an enforced painstaking cheese-paring economy which is common enough with nations whose standard of living is low, but unknown, among the people of a wasteful and well-to-do modern industrial state. In this event the old rag and bone man of early and middle Victorian days will be reincarnated as a duly uniformed, badged minor official supervised by various committees and become part and parcel of our social life.

The rag and bone man was representative in his day of the lowest rung of the mercantile social ladder; he dealt in the cast-off rubbish to which in times of peace and greater wealth the community set no value. He cadged a very great deal of the material in which he dealt; rags, bones, bottles, tins, old pots and pans were all fish for his net so long as they could be carried away in his hand cart. Of the rags the woollen went to make shoddy, and in due time clothe a certain number of citizens. The linen and calico rags went to the high-grade paper trade; bottles were either washed and sold to local users, or broken and sold as "cullet" for remelting in the bottle trade. The bones went to make glue or fertilisers. The new hygienic standards of the late nineteenth and early twentieth centuries drove this picturesque unsavoury figure from the streets. The sanitary dustbin and the municipal dustman replaced him. The festering rubbish heap and the municipal dust destructor were the destination of much that the rag and bone man had collected.

To-day, waste paper and cardboard containers of all sorts will go back to the paper mills to reduce our needs for imported wood pulp. The cabbage leaf, peelings of potatoes, and other food refuse should find their way to feed pigs. The bones can follow their old course, with the exception that they will provide both glue and glycerine as well as fertilisers. The rags of wool, cotton, and linen are again recognisable as worthy of a better fate than the fires of the municipal dust destructor. Tobacco and food tins will be melted with the old ploughshares and broken harrows rusting in our farms. The local dispensing chemist is thankful for the return of the medicine bottle. The grocer with a licence to deal in such fluids is glad to have back the beer and cider bottle—soon they may approach in value to the soda water siphon.

For the moment the old and derelict car is an exception. The progress of the worn-out engine and gear-box, of the chassis and other metallic parts to the melting pot are temporarily arrested—"The faithful Rolls having had its day, may block a road and keep the Hun at bay." All the same, the aluminium crank cases might be abstracted without detriment to the potential obstructive value of the vehicle.

Within their own works the practice of the average engineering manufacturing firm in its collection and disposal of its internally produced scrap and swarf was unimpeachable. There is no occasion for them to don Omar Khayyám's winter garment of repentance as their fellows needs must do to-day. In many cases the hastily improvised means of collection will cost very much more than the material is normally worth, but perhaps justifiably in an emergency. Whatever may happen after the war to the refuse which we now regard as salvageable, the parallel question of the attitude of our post-war society to the question of waste will be an interesting one which perhaps may not admit of treatment on what we once regarded as orthodox economic lines. Before we became slaves to the machine, sacrificing sweated individual handcrafts in some trades and the better-paid craftsmanship of other trades on the altars of mechanised industrialism, there was no problem of leisure, other than that of the recurring cycles of depression with accompaniment of a dire poverty that had no such alleviation as is available through the Unemployment Assistance Board or the out-of-work payments of the Labour Exchange.

As there was very little leisure things were made to last.

Up to a year ago with more abundant leisure some began to wonder whether it was permissible to make anything which was not so flimsy, so cheap, and so trashy as to require very quick replacement. To such it would have appeared that in the Erewhon books of Samuel Butler there was a distinct omission; there should have been at least one law case chronicled in which Mr. Nosnibor (being a manufacturer of paints) was prosecuted on the charge that he had provided the painters of the lampposts in the capital with pigment of such good quality that these lampposts after two or so years did not require repainting. Mr. Nosnibor would have had two lines of defence. In the first his counsel would have submitted the defence that he had placed orders from the suppliers of his raw material for the ordinary inferior quality rubbish. Inadvertently those suppliers had supplied a superior quality and that this happening had unfortunately been overlooked in mixing the pigment and its vehicle. With this defence his plea would have been an accidental occurrence due to a third party and that he was not guilty of a deliberate infringement of the code that commodities were made to be consumed and not to endure, in order that more and more people might find employment in producing and using ephemeral products altogether lacking in durability. And/Or his counsel would plead that ordinary cheap rubbish of beautiful initial appearance had been supplied, but that a perverse foreman painter had wire-brushed a rusty surface, had poured away the "thinner" issued to him, and had carried out the work of applying the paint to a dry surface on a fine day. The Court would then be left with the problem of determining whether or not the defence was a good one, in which case other parties would become liable to prosecution.

It is easily possible to imagine other trials in the courts of Erewhon all suggestive in one aspect or other of future interrelated problems of durability and of unemployment, of simple utility, and of ornate waste. One wonders what we and/or our successors will do about them.

Sixty Years Ago

The Reese Fusing Disc

"Day by day additional evidence is supplied that we know next to nothing concerning molecular physics. At one time we are startled by Mr. Crooke's discoveries, and we hear of a fourth state of matter. Then the telephone and afterwards the microphone taught us that much yet remained to be learned concerning the interaction of particles or molecules in apparently the most rigid substances." So we wrote in our issue of October 8th, 1880, by way of introduction to an article on the Reese fusing disc, the action of which, we suggested, afforded more matter for wonder than even the microphone itself. The Reese disc, we explained, was not a laboratory instrument, but was actually in use in several American ironworks and machine shops. We had obtained first-hand information concerning it from Mr. Jacob Reese, himself at Pittsburg. The disc was employed to cut bars of round steel. The machine resembled a cold saw, but instead of the circular saw it had a plain disc of soft steel, $\frac{5}{16}$in. thick, 42in. in diameter, and running at about 2300 r.p.m. The bar to be cut had to be round. It was fixed in a chuck and caused to turn in the same direction as the disc at about 200 r.p.m. The edge of the disc and the surface of the bar adjacent to it then moved in opposite directions. When the disc was brought up towards the bar but not touching it, the bar was fused through. The cut was $\frac{5}{16}$in. wide and observation showed that as the feeding forward of the disc continued the disc edge was always $\frac{1}{4}$in. clear of the bottom of the cut. The ends of the bar being fused, Mr. Reese informed us, became hot, but showed no signs of having been touched by the disc. On the other hand, the disc remained perfectly cool. The material fused from the bar was metal and not oxide, and although it came away molten, it could, while running down, be caught by the naked hand without detecting any great rise of temperature. It was emphasised that the bar to be cut must be round and must be rotated. If it were held stationary the disc cut its way through the bar as a cold saw would, and the discharge from the cut was not metallic, but an oxide of iron. A round steel bar, $1\frac{3}{4}$in. diameter, could be fused in from two to ten seconds. Mr. Reese sent us his own explanation of the phenomenon. It was based on the occluded heat in the air thrown off from the disc. His explanation, we said, was a little hard to follow, but we suggested that a portion of the bar was first fused by the disc coming into contact with it. The steel thus melted was burned by the air current, and the heat thus generated burned the rest of the bar without the disc again coming into direct contact with it. We admitted that this explanation failed to account for the fact that the product of the fusing was metallic and not an oxide of iron. Mr. Reese, we said, was a metallurgist of some standing, and we had no reason to doubt the truth of his statements. We left the subject for the time being in our readers' hands, and suggested that it might stimulate the energies of ingenious minds for some time to come. It was, we said, very difficult to explain the phenomenon on any hypothesis consistent with our existing knowledge of molecular physics.

Literature

SHORT NOTICES

An Air-Conditioning Primer. By William Hull Stangle. McGraw-Hill Publishing Company, Ltd., London. 1940. Price 16s. 6d.—Many books on air conditioning have been published in the last few years, but the author of this work believes that "few are editorially sound, while none has seemingly attempted to place the simple fundamentals and essentials within the hands of those interested." In carrying out his intention to remedy this omission, the author divides his work into two parts, the second about twice as long as the first, entitled respectively "Fundamentals," and "Application and Apparatus." About half the length of the book is devoted to descriptions and illustrations of apparatus, how it is arranged, and the principles of its operation. Under "Fundamentals" such subjects as heat, the properties of air, and the workings of the human body are dealt with.

Acoustics. By Percy L. Marks. London: The Technical Press, Ltd. 1940. Price 7s. 6d.—This work is not an exhaustive treatise on acoustics. It is, in fact, chiefly concerned with the subject as it affects architects. The first part of the book is mainly composed of the views of those who have conducted researches on the subject; and the second part consists of excerpts from booklets and catalogues issued by firms associated with various systems or materials of an acoustic character. Four appendices are added. The first is drawn from Professor Floyd R. Watson's "Acoustics of Buildings," and deals with the time of reverberation in auditoriums; the second is a communication from the N.P.L. on the design of concrete floors to reduce the transmission of sound; and the last two consist of some remarks on flats for the masses, considered acoustically, based upon a Ministry of Health report, and extracts from an article by Mr. F. Gibberd on a flat group, which first appeared in the *Architects' Journal*.

BOOKS RECEIVED

Power Pumps. By C. Edwards. Epsom: Draughtsman Publishing Company, Ltd., 1, Links Road. Price 2s.

The Microscope. By R. M. Allen. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 15s.

Automatic Lathes and Screw Machines. By E. T. Westbury. London: Percival Marshall and Co., Ltd., 60, Kingsway, W.C.2. Price 2s.

Electricity Applied to Marine Engineering. By W. Laws. High Wycombe: Institute of Marine Engineers, 73, Amersham Road. Price 5s. 6d.

Locomotive Valves and Valve Gears. By C. S. Lake and A. Reidinger. London: Percival Marshall and Co., Ltd., 60, Kingsway, W.C.2. Price 5s.

Engineering Surveys. By H. Rubey, G. E. Lommel, and M. W. Todd. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 15s.

Mechanical Testing of Metallic Materials. By R. A. Beaumont. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 6s.

The Iron and Steel Industry. By G. Brown and A. L. Orford. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 6s.

Radio-frequency Measurements by Bridge and Resonance Methods. By L. Hartshorn. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 21s.

Production Engineering: Jig and Tool Design. By E. J. H. Jones. London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 12s. 6d.

The Health and Efficiency of Munition Workers. By H. M. Vernon. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 8s. 6d.

An Introduction to the Kinetic Theory of Gases. By Sir James Jeans. London: Cambridge University Press, Bentley House, 200, Euston Road, N.W.1. Price 15s.

South American Iron Ore.—A recent survey of Brazil's mineral resources shows that the country possesses over 20 per cent. of the world's known reserves of iron ore, mainly situated in the State of Minas Geraes. Brazil's production of iron and steel has increased progressively in recent years, that of pig iron from 35,000 tons in 1930 to 148,000 tons in 1939, the corresponding figures for steel being 21,000 tons and 111,000 tons, and for laminated iron 26,000 tons and 97,000 tons. Brazil's imports of raw iron and steel in 1939 amounted to 91,000 tons, and those of iron and steel manufactures to 237,000 tons, a large part of which was supplied by Germany and Belgium.

Multiple-Gang Flush Riveter

The riveter illustrated herewith, and known as the type G M R universal multiple-gang flush riveter, will head in one operation in a single stroke a number of flush type rivets—ten to sixteen—along a straight line and on flat sections. It is made by the General Engineering Company of Buffalo, N.Y., for which A. C. Wickman, Ltd., are sole agents in this country.

The principle of operation is the same as in any press. Two anvils approach to the proper distance, and squeeze a flat head rivet of the required thickness. A pressure pad, consisting of two thin-edged rails on each side of the anvil, holds the sheets firmly together while the head is being formed. The machine has enough rigidity and power to limit the number of rivets formed at one time only to the number that can be accommodated within the dimensions of the anvils. The anvils of a typical installation accommodate ten $\frac{5}{32}$in. flush type rivets, spaced $\frac{3}{4}$in., or sixteen $\frac{1}{4}$in. rivets, spaced $\frac{1}{2}$in. The upper and lower heads or anvils are quickly replaceable by means of two socket head screws on each. This makes it possible to use the machine for a wide combination of rivet patterns and variations in shape of riveted parts. Only a few minutes is required for changing set-ups. It is also possible to replace the riveting heads with heads for punching or press countersinking single holes or gangs of holes. Quite heavy forming and punching can be done, as the machine will develop about 50 tons pressure over the last $\frac{1}{4}$in. stroke.

No adjustment of the closing gap between riveting anvils is necessary, as the machine forms the proper size head automatically, regardless of the rivet grip. This is a great advantage on assemblies where different sizes of rivets or where changing combination of sheet thicknesses may be present. This control is accomplished by means of an electrical limit switch

Multiple Gang Flush Riveter

operated by means of the deflection of the pressure pad as the rivet head is formed. The air valves are actuated by electric solenoids. When the foot control is depressed the solenoid opens the air valve. The pressure pad remains stationary after it has squeezed the sheets together as the lower riveting anvil continues its upward motion. It continues to the point where the proper size head is formed. At that point electrical contact is made by a precision limit switch and the air is reversed. A handle selector makes it possible to change from the proper size head for one rivet diameter to that for another.

A handle control is also provided for changing the total travel of the ram. The ram has two ranges—a short working and a long loading range of travel. A third handle controls the speed of the ram. The ram can be inched up or down at an infinitesimal rate, or the up or down cycle can be speeded up to take less than a second.

The power is supplied by an air cylinder connected to a toggle. Air at 80 lb. per square inch minimum pressure is required. The machine will consume 5·1 cubic feet of air per minute, operating at ten strokes per minute. The bottom head moves up and down $\frac{3}{4}$in. with the hand lever in one position. This is the amount most satisfactory for general riveting. This $\frac{3}{4}$in. can be varied by a minor alteration inside the machine. When riveting work has high obstructions which must be cleared to load the work, the lever may be pulled to the other position. Operating the foot pedal then provides a $3\frac{3}{4}$in. ram travel. The ram, however, may be stopped at the $\frac{3}{4}$in. opening or at any other point, if desired to start a riveting operation by means of the speed control lever.

The machine's frame is a welded steel plate box section with lateral stiffeners where required. A chamber is separated from the part of the frame which houses the air valves and toggle mechanism by an air-tight bulkhead. This air-tight section serves as a reservoir, feeding the cylinder with a full head of air. It makes the speed of the cylinder operation nearly independent of the size of piping to the machine and the distance from the compressor.

The throat or reach of the machine is 36in. and the gap 15$\frac{1}{2}$in. The riveting height is 44$\frac{1}{2}$in. from the floor, and the machine requires a floor space of approximately 30in. by 80in. The weight is about 6000 lb., and the overall height 83in.

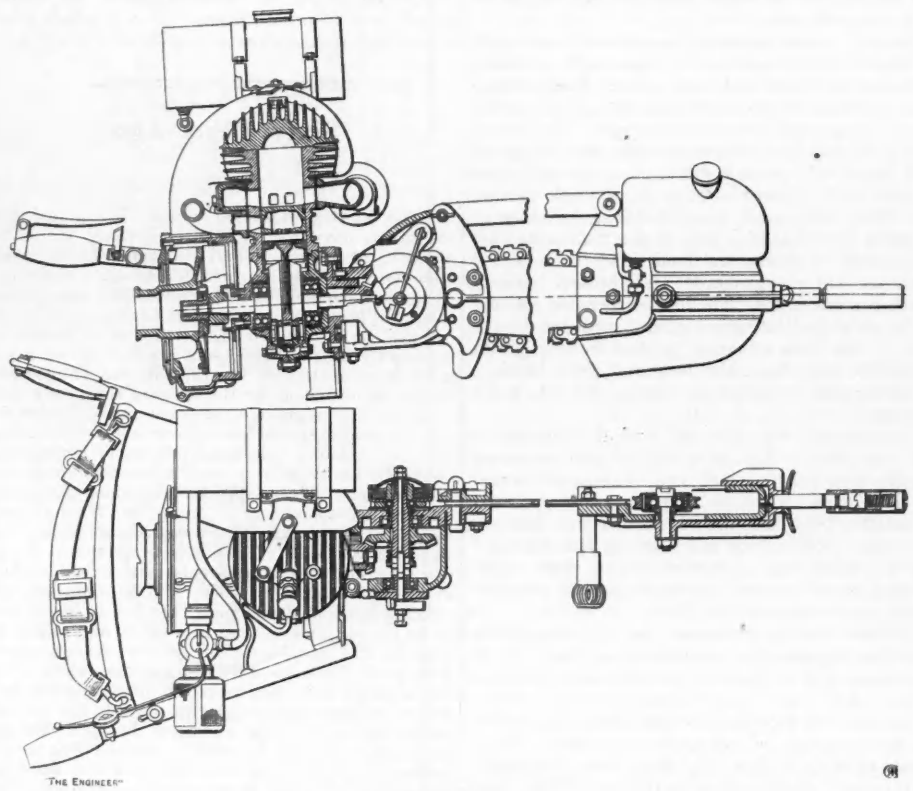
It has been found with this system of riveting that work is best handled by setting up on either side of the machine large tables with rollers spaced about a foot apart on their tops and at the same height as the riveting anvil. If stiffeners are being riveted to a panel skin, for example, the procedure would be to have the holes already in the skin and dimpled, and the holes in the stiffener transferred from the skin and dimpled or machine countersunk. The parts would then be temporarily assembled in the regular manner by use of screws or patented clips. These operations all precede placing the temporary assembly on the roller feed tables for the gang riveter. Then one operator can slide quite large assemblies back and forth under the riveting anvil without a helper. A helper is of assistance in putting work on to the roller table and placing rivets.

The anvils or heads can be rotated on their axis. It is sometimes easier to rotate the anvils than to swing the work, and it provides a means of riveting short pieces placed transversely to a long strip—such as ribs on ailerons or flaps. A means is provided for quickly locking the head at any angle of rotation.

The "Danarm" Saw

The accompanying drawing shows the details of a petrol engine driven chain saw that has been developed by T. H. and J. Daniels, Ltd., of Stroud, in conjunction with Mr. J. Clubley Armstrong, of Abford House, Wilton Road, London, who is putting it on the market. Little need be said about the arrangement of the tool, which is very clearly indicated in the drawing. The power unit is a Villiers two-stroke air-cooled petrol engine, and the petrol tank holds rather more than half a gallon of fuel. The motive power developed in the engine crankshaft is transmitted through bevel gears in the gear-box, and an external laminated friction clutch to the chain sprocket. The clutch is attached to the outside of the gear-box, and allows for a resilient drive to the chain saw. In the event of the saw encountering an overload, such as might be created by a knot, the clutch is designed to slip, with the result that wear on the engine and the chain saw itself is reduced. The pressure across the clutch is adjustable. Top and bottom grooves of the saw guide plate are fitted with interchangeable wearing strips. The teeth in the chain are disposed in three batches of six right and left-hand cutting teeth ground straight across the tops, $\frac{1}{16}$in. above bent raker teeth; right and left-hand bent raker teeth ground straight across, and tops $\frac{1}{32}$in. above straight raker teeth; and right and left-hand straight raker teeth ground straight across, respectively. The makers are able to supply a complete grinding set for grinding the saw teeth. It is driven by flexible shaft from the engine.

For various cutting operations the saw guide plate together with the gear-box can be tilted into five positions in relation to the engine unit. It can be vertical to the ground, in the normal position for cross cutting, or horizontal with the cutting side facing the operator's right hand. It can also be arranged horizontal with the cutting side facing the operator's left hand, but this condition is only permitted in order to meet awkward tree-felling operations, and as the oil flow is not arranged for this emergency, the chain needs to be lubricated by hand. The guide plate can also be set to a 45 deg. angle, either to the left or the right, for cutting the notch in the tree.



Petrol Engine Driven Chain Saw

A Producer Gas Utility Car

A utility car for the conveyance of works executives is the latest addition to the fleet of producer gas driven vehicles converted and operated by the Northern Aluminium Company, Ltd. The car is intended for transport between the company's three works, and is required to undertake single journeys, ranging from a minimum of 45 miles to a maximum of 100 miles. The conditions are therefore very favourable for producer gas operation.

The body, which is mounted on a standard Morris 25 H.P. chassis, was specially designed for the incorporation of a Brush Koela producer in a compartment at the rear. A problem raised by this arrangement lay in the difficulty of successfully dissipating waste heat from a confined space, but this has been overcome by the provision of specially designed ventilation. Hinged windows at the sides, opening forward, and a floor of heavy wire mesh cause a strong draught to be induced when the car is in motion, the heated air being allowed to escape through sliding windows and a large louvred vent in the rear doors. The interior of the producer compartment is insulated throughout with linings of asbestos and metal sheet.

The Brush Koela producer incorporates the latest type of filter for cooling and cleaning the gas. The first-stage cleaner, mounted at the offside, is designed to remove the bulk of the solid impurities and to lower the temperature of the gas. The second stage is carried out by means of two "can" type purifiers installed below the roof, the first containing water and the second oil. These "wet" purifiers remove injurious constituents such as silica, sulphuric acid, sulphur trioxide, and ammonia, and any remaining solid particles, whilst the oil purifier also provides to a certain extent upper cylinder lubrication. The sulphurous acid, which is not absorbed by the water, is removed by ferric chloride provided by chemical action in the second stage.

All parts of the plant are placed so as to be readily accessible for easy operation and regular servicing. The valve for changing from cross to up draught, for example, is operated by cable from the driver's seat. One particularly interesting feature in the arrangement of the plant, designed to assist cooling, is the

forming of the gas tube from the fire-box into a large loop under the car.

Initial trials, we are informed, have shown the performance of the vehicle, which has a total weight of just under 2 tons, to be very satisfactory. Using "Suncole" fuel, a range of approximately 100 miles is obtained on one filling of the hopper. Speeds of 40 to 50 miles an hour can be maintained comfortably on average roads, the maximum speed on the level being over 55 miles an hour. Starting is

PRODUCER GAS PLANT IN UTILITY CAR

found to be very easy. On one occasion a start was obtained on petrol, without relighting the fire, after a standing interval of 3½ hours.

The body of the vehicle was supplied by Hartwells, Ltd., of Oxford, who, as the Brush Koela agents for Oxfordshire and district, also installed the producer.

Road Marker

THE accompanying engraving illustrates the "Rytecraft Safeti-Line" road marker made by B.H.B. Engineering Company, of Britannia House, Ampton Street, London, W.C.1. This machine has an overall length of 3ft. 6in., a width of 2ft. 8in., and a height adjustable from 32in. to 38in. It is driven by a ¾ H.P. air-cooled petrol engine. The whole device is mounted on 16in., 4in. pneumatic-tyred wheels carried on roller bearings. Paint is sprayed on to the road surface. The spray gun is very quickly

"SAFETI-LINE" ROAD MARKER

detachable, and can be used for other spraying jobs, such as gutters, lamp posts, and obelisks, &c. Any kind of quick-drying paint can be used. The pressure with which it is delivered is controlled by a specially designed gear pump. When the flow of paint to the gun is stopped, the paint circulates back to the tank, and is thus left in a constantly agitated condition. The pump is driven through a vee belt. The paint is contained in an air-tight tank holding 7 gallons. The width of the strip painted can be varied between 3in. and 9in., and the marking speed lies between 2 and 4 miles per hour, according to conditions. On each side of the spray gun there is a shield and the arrangement, the makers claim, is such that sharp definition of the lines is ensured. By reference to the engraving it will be seen that the engine exhaust is arranged to blow across the path of the spraying unit, thus removing dust from the surface.

A NEW ALLOY.—An American metallurgical firm has produced a new grade of Kennametal tungsten-titanium carbide alloy, which, it is claimed, combines unusual hardness with toughness. It is recommended as a tool tip material for light finishing cuts and for fairly heavy continuous cuts on steel of all hardnesses up to 550 Brinell.

Conversion of Petrol Vehicles to Operate on Town Gas*

By E. A. C. CHAMBERLAIN, Ph.D., D.I.C.

WHEN a simple conversion of a petrol vehicle is undertaken, it is understood that minimum alterations will be made to the engine, and that either petrol or gas may be used at will. The primary consideration of such a conversion is that the cost of the alterations shall be as low as possible, consistent with reasonable performance on the alternative fuel, and that the performance on petrol shall not be adversely affected by any of the alterations made. Secondly, it is important that any driver should be able to change from one fuel to another easily and rapidly. These restrictions operate against optimum performance on gas, and possible improvements in engine performance have to be rejected in view of high cost of alteration or resulting difficulties when running on petrol.

THE PERFORMANCE OF AN ENGINE AFTER CONVERSION

Power Output.—The power development of a particular engine is entirely dependent on the properties of the fuel supplied to it, and will vary with different fuels. It has been found that town gas gives a smaller power output than petrol, and it has been thought advisable to review the theoretical considerations involved in order to check the experimental results obtained on the test bed. The chief considerations are :—

(1) The net calorific value of the fuel air mixture.
(2) The specific volume change on combustion.
(3) The specific heats of the products of combustion and the degree of dissociation at high temperatures.
(4) The latent heat of evaporation of the fuel if liquid.
(5) The specific gravity of the fuel/air mixture.
(6) The radiation from the flame and hot products.

The two fuels between which comparison has been made are No. 3 petrol, as specified in Technical Data on Fuel, and town gas of the following analysis :—

CO_2, 2·5 ; O_2, 0·6 ; C_3H_6, 2·6 ; CO, 10·8 ; CH_4, 21·1 ; C_2H_6, 0·7 ; H_2, 54·4 ; N_2, 7·0.

500 B.Th.U. per cubic feet gross, 456 B.Th.U. net.

When running on gas the fuel/air ratio for optimum power is about 1 : 4·1 by volume, so that the fuel/air mixture entering the cylinder on each induction stroke consists of 80 per cent. air and 20 per cent. fuel. On petrol the fuel enters in the form of a heavy vapour occupying under 2 per cent. of the total volume inspirated. There is therefore in effect a loss in volumetric efficiency when operating on gas.

The following figures are taken as a basis of comparison between the two fuels :—

	No. 3 petrol.	Town gas.
Calorific value of theoretical fuel/air mixture (air 60 per cent. RH, 60° F.)	95·0 B.Th.U. per cubic foot	85·2 B.Th.U. per cubic foot
Specific volume change on combustion, *i.e.*, volume of products net at S.T.P./volume of mixture at S.T.P.	1·062	0·915
Mean specific heat of products of combustion, 0–2200° C.	0·02385 B.Th.U. per cubic foot	0·0244 B.Th.U. per cubic foot
Latent heat of evaporation	254 B.Th.U. per pound	—
Specific gravity of the fuel/air mixture	1·04	0·89

It is not possible to estimate singly the effect of these factors, since they are all interdependent, but it is possible to indicate their general significance.

The difference in calorific value of the fuel/air mixtures is 10·3 per cent., and this is the most important of the factors tending to reduce the power output on gas, but it must be considered in conjunction with factors (2) and (3). The specific volume change indicates an expansion of 6·2 per cent. on petrol and a contraction of 8·5 per cent. with gas, so that the ratio of volumes after combustion is

$$V\ gas/V\ petrol = 0{\cdot}861.$$

This factor obviously reacts in favour of petrol, since it tends to give a bigger pressure development in the cylinder with a lower working temperature. However, the higher specific heat of the products of combustion of town gas tends to reduce the flame temperatures. The combined effect of these three factors may be considered as follows :—The theoretical flame temperature (ignoring dissociation) is

With petrol : 2080 deg. Cent., 2353 deg. A.
gas : 2120 deg. Cent., 2393 deg. A.

The effect of this difference on the pressure development is of the order of 1·5 per cent. in favour of gas. Considered in conjunction with the V gas/V petrol ratio, 0·861, the ratio of pressures developed at constant volume under these ideal conditions will be

$$0{\cdot}861 \times 1{\cdot}015 = 0{\cdot}875\ ;$$

so that the pressure development on gas is less by 12·5 per cent.

It is interesting to note the effect of rich mixtures on the specific volume change which occurs with both gas and petrol. Taking, for example, town gas :—

	Theoretical mixture for complete combustion.		
Air/gas ratio	4·3 : 1	4 : 1	3·5 : 1
Specific volume change	0·915	0·956	0·974
Potential heat in flue products	Nil	8·6%	22·4%

This increase is due to the large number of molecules owing to the existence of some carbon monoxide and hydrogen in place of carbon dioxide and water vapour. The actual power developed will, of course, depend on the balance between the increase in the specific volume change and the decrease due to the loss of heat developed. The figures given indicate that the maximum power mixture will be about 4·1 : 1. Burstall, working on a single-cylinder engine, found that maximum power was obtained with a 20 per cent. rich coal gas air mixture (*i.e.*, an air gas ratio of 3·82 : 1) ; but this result was obtained by adjusting ignition timing, valve setting, &c., to give the optimum power, and not under simple conversion conditions. We have found in experiments on a Commer 14/4 and an Austin 16/6 that the maximum power is obtained with the mixture giving an exhaust analysis of 10 per cent. CO_2 and 1·4 per cent. CO on gas of the composition previously given. This corresponds to an air gas ratio of 4·14 : 1, a result very close to that obtained theoretically.

The latent heat of evaporation of the fuel has a considerable effect on the volumetric efficiency of the engine, since with petrol the air fuel charge is cooled by about 28 deg. Cent. If the temperature of the charge drawn into the cylinder is taken as 380 deg. A, the result of this cooling effect is to increase the volumetric efficiency by about 7 per cent. On gas this intrinsic cooling effect is absent, and the working temperature of the cylinder will also be higher, so it may be anticipated that the warming of the entering charge by convection on the cylinder walls will be greater with gas than with petrol, and that the temperature difference will be increased.

The differences in viscosity and specific gravity of the air/fuel mixture will become important as far as these factors influence the discharge characteristics of the two mixtures through the valve gear. It is not possible to calculate for a general case the value of this effect, but the equivalent effect on any engine will be inversely proportional to the square roots of the densities of the two mixtures. Here the advantage lies with town gas, since

$$\sqrt{d_{petrol}/d_{gas}} = \sqrt{1{\cdot}04/0{\cdot}89} = 1{\cdot}08.$$

Cooling Losses from the Burning Charge.—It is necessary at this point to consider what differences exist in the energy dissipation with gas and with petrol. Little data are available on the conduction from hot gases to the cylinder walls under the conditions of turbulence that exist in an engine cylinder. At low temperatures (100 deg. to 500 deg. Cent.) the rate of cooling is proportional to the temperature difference between the hot gases and the walls of the cylinder. The percentage loss by conduction will therefore vary as the surface volume ratio of the cylinder, and will therefore be lower as the diameter of the cylinder increases, an important factor when comparison is made between the large-bore gas engine and the relatively small-bore multi-cylinder high-speed petrol engine converted to gas. At elevated temperatures, however, the simple temperature difference relationship is not valid. According to David, the rate of cooling increases rapidly at higher temperatures, being proportional to the second power of the temperature difference at 1500 deg. Cent., and to as much as the fifth power at 2400 deg. Cent. It will be realised therefore that though the calculated flame temperatures of gas and petrol differ by only 40 deg. Cent., the effect on the conduction losses may well be more significant.

The radiation losses may be considered as arising primarily from the carbon dioxide and water vapour contents of the explosion products (Schack). As pointed out by Bone and Townend, it might be supposed that as gases under suitable conditions are capable of absorbing the radiations which they emit, they would therefore be opaque to such radiations, but it must be remembered that the molecules are relatively far apart, and hence a large percentage of the radiations escapes. Callendar arrived at the conclusion that the emission from a gas layer 5 cm. thick at 20 atmospheres would be within half of 1 per cent. of that from an infinite depth.

It is possible therefore to calculate approximately the radiation for the two air fuel mixtures being considered. The simplified formula recently proposed for estimating these losses is :—

$$Q\ CO_2 = 3{\cdot}5\ \sqrt[3]{PS.}\,(T/100)^{3{\cdot}5}$$
$$Q\ H_2O = 35.P^{\cdot 8}\ S^{\cdot 6}\ (T/100)^3$$

Where Q = radiation in K cal/m²hr.
P = partial pressure in atmospheres.
S = depth of radiating layer in meters.
T = temperature, deg. A.

Radiation from other gases present can be ignored.

The exhaust gas analysis (wet) at theoretical fuel/air ratio for petrol and town gas is as follows :—

	Petrol.	Town gas.
CO_2	12·9	9·9
H_2O	13·3	20·4
N_2	73·8	69·7

The difference is appreciable, and in practice it

* Institute of Fuel : Abstract.

will be still further emphasised by the CO and H_2 present in the products from petrol which will reduce the CO_2 and H_2O percentages. As an example, the radiation from the two exhaust gases has been calculated for a pressure of 20 atmospheres at 2500 deg. Cent. with a radiating layer 6 cm. deep.

Petrol	$Q\,CO_2$ = 268,000	K cal/m² hr.
	$Q\,H_2O$ = 533,000	,, ,,
$Q\,CO_2 + Q\,H_2O$ = 801,000		,, ,,
Gas	$Q\,CO_2$ = 245,600	,, ,,
	$Q\,H_2O$ = 753,000	,, ,,
$Q\,CO_2 + Q\,H_2O$ = 998,600		,, ,,

Under these conditions, *i.e.*, identical flame temperatures, there is with gas 23·6 per cent. more radiation from the products of combustion. It should be remembered that this computation ignores radiation from incandescent carbon particles in the flame.

It has not been possible to obtain any figures of direct conduction and radiation losses from an engine operating on gas or petrol, but the following determination of jacket losses shows that there is a greater heat loss to the walls when operating on gas than on petrol :—

Gas		
Revolutions per minute ...	1,000 ...	1,500
Brake horsepower...	13·6 ...	19·6
Gas rate, cubic feet per hour	372 ...	530
Heat input, B.Th.U. per hour	185,500 ...	264,000
Temperature rise in cooling water, deg. Fah.	71 ...	86
Heat content of cooling water, B.Th.U. per hour	80,250 ...	100,000
Jacket loss, per cent.	43·2 ...	37·9
Power development, per cent. heat input	18·7 ...	18·9
Petrol		
Revolutions per minute ...	1,000 ...	1,500
Brake horsepower...	13·6 ...	19·6
Petrol consumption, gallons per hour	1·3 ...	1·8
Heat input, B.Th.U. per hour	195,000 ...	270,000
Temperature rise in cooling water, deg. Fah.	66·5 ...	86·0
Heat content of cooling water, B.Th.U. per hour	72,500 ...	93,800
Jacket loss, per cent.	37·2 ...	34·5
Power development, per cent. heat input	17·8 ...	18·5

Loss of Potential Heat in Exhaust Gases.—The optimum power setting on a petrol engine requires a rich fuel/air mixture, and as a result an appreciable part of the exhaust loss is made up of potential energy of unburned gases. A typical analysis on petrol would be :—

CO_2	10%	H_2	2·8
O_2	1%	CH_4	0·25
CO	5%	N_2	80·95

This potential heat corresponds to about 17 per cent. of the gross calorific value of the fuel. The optimum power setting on gas is also on the rich side of the neutral mixture, but in a simple conversion it is found that enrichment beyond 105 per cent. of the correct mixture fails to increase the power developed. It follows that on petrol the waste heat includes up to 6·9 per cent. of the gross C.V. as latent heat plus 10 to 12 per cent. as potential heat, while on gas up to 10 per cent. is present as latent heat and the potential heat in unburned products is small. If two engines are running on petrol and town gas at equal thermal efficiencies the amount of sensible heat is therefore greater on gas than on petrol.

Summing up the foregoing considerations, it is possible to express the percentage power loss on simple conversion of a petrol engine to gas in the form

$$\text{Loss per cent.} = 100\,(1 - f \times \text{volumetric efficiency ratio} \times F),$$

where f = a factor involving calorific value of the fuel/air mixtures, specific heat of the products of combustion, and specific volume change. In other words,

f = the ratio of pressures developed by explosion of equal volumes of the two fuel/air mixtures at constant volume.

F = an indeterminate factor involving flame characteristics, convection and radiation losses, greater than unity.

$$\text{Power loss} = 100\,(1 - 0{\cdot}875 \times 0{\cdot}93 \times F)$$
$$= 100\,(1 - 0{\cdot}814\,F).$$

It is therefore to be expected that under the conditions of simple conversion the power loss will not be less than

$$100\,(1 - 0{\cdot}814) \text{ per cent.}$$

Power loss = 18·6 per cent. of the power on petrol.

Experimental Determinations of Power on Gas and Petrol.—Burstall gives a comparison of petrol and gas on a single-cylinder test engine (Cambridge E.35) at 1500 r.p.m., at a compression ratio of 5 : 1. I.M.E.P. on petrol 141, on gas 126 lb. per square inch, corresponding to a power loss of 10·7 per cent. This figure must be regarded as ideal, since the engine was specially tuned to obtain maximum power on both fuels.

Walter quotes the following results for the simple conversion of a 7 H.P. four-cylinder engine :—

	On petrol.	On gas.
Maximum B.H.P.	11·2 ...	7·4
Fuel consumption per B.H.P. per hour, cubic feet	— ...	27
Brake thermal efficiency, per cent....	22·6 ...	19·6

Loss of power on gas, 34 per cent.

The same author states that on engines with the C.R. increased to 6·5 : 1 it is possible to obtain with town gas 85 per cent. of the power on petrol, and 90 per cent. if the hot spot in the induction system is removed.

Rixman did complete tests with gas and petrol on two engines—(1) a slow-running six-cylinder engine of 120 mm. bore by 160 mm. stroke, normal speed 1250 r.p.m.; (2) a high-speed six-cylinder engine, 79·4 mm. bore and 117·5 mm. stroke, maximum speed 3200 r.p.m. Engine No. 2 had marked preheating of the induction system. His results are given as follows :—

Engine 1

Speed.	Loss of power, per cent.
700	20
900	21·5
1100	19·5
1300	14
1500	9·5

Engine 2

Speed.	Loss of power, per cent.
1200	21
1600	19
2000	22
2400	24
2800	25

Our own test results may be summarised as follows :

Engine.	R.p.m.	Gas.	Petrol.	Per cent. power loss on gas.
Commer 14/4...	2500	20·1	30·0	33·0
Austin 16/6	2500	30·2	39·4	23·4
M.G. Sports	4500	30·2	42·0	28·0

These results were obtained on unmodified engines.

As would be expected, these results indicate that the loss of power on typical small high-speed engines is greater than on the larger cylinder type of slow-running engine. It is therefore possible to anticipate that the power losses on vehicles converted to town gas will be :—

(1) Lorries with slow-running engines, 15 to 20 per cent.

(2) Light vans and private cars, 20 to 30 per cent.

Thermal Efficiency of the Engine.—Heat that is not converted into work is left to raise the temperature of the cooling water and of the exhaust gas, so that the higher the efficiency, the lower the waste heat must be. This effect is bigger than is at first evident. For consider two engines, one giving 18 per cent. efficiency and the other 25 per cent. At the same heat input the waste heats are in the ratio of 82/75 = 1·1. If, however, a comparison is made on the basis of equal brake horsepower output, the waste heat ratio is

$$82/75 \times 25/18 = 1{\cdot}52.$$

So that the less efficient engine when working at the same power output has 52 per cent. more waste heat to dissipate.

The conversion of a petrol engine does not necessarily reduce the thermal efficiency; indeed, under the right conditions slightly higher efficiencies than with petrol can be obtained. With simple conversions these conditions are not attained. As a result, it appears that the efficiencies of gas conversions are often slightly lower than on petrol. Dynamometer tests show that between 25 and 30 cubic feet per brake horsepower may be expected for a normal conversion. Typical results obtained are as follows :—

14/4 *Commer ; Carburetter G.L.C., No.* 1

R.p.m.	Cub. ft./ B.H.P./hr.	Efficiency, per cent.
1500	30·8	16·6
2000	27·4	18·6
2500	29·0	17·6
3000	28·6	17·9

16/6 *Austin ; Carburetter G.L.C. No.* 2

R.p.m.	Cub. ft./ B.H.P./hr.	Efficiency, per cent.
1500	27·4	18·6
2000	28·0	18·2
2250	25·0	20·4
2500	27·6	18·5

C. M. Walter and J. S. Clarke do not give actual efficiency figures in this form except for an engine with the compression ratio increased to 5·6 : 1, but from curves drawn for the engine (Austin 20/6) in its original form with a compression ratio of 4·6 : 1, it appears that the best efficiency on gas was 20·5 per cent., equivalent to 24·8 cubic feet per brake horsepower per hour, with a calorific value of 500 B.Th.U. per cubic foot.

For the modern petrol engine the corresponding consumption may be taken as 0·6 pint per brake horsepower per hour, which corresponds to an efficiency of 22·6 per cent. While these figures may be taken as an average on grade 1 petrol, our own results on the Austin 16/6 running on Pool petrol indicate a consumption of 0·65 to 0·7 pint per brake horsepower per hour, giving efficiencies between 20·9 and 19·4 per cent.

The Influence of Ignition Timing.—It has been found on road tests with vehicles fitted with manual ignition control (Ford 24·9 H.P. van and a Morris Commercial 14 H.P. van) that the optimum ignition setting on gas was only slightly in advance of that for petrol, whereas it is generally considered that a large ignition advance is desirable. The following test on the Austin 16/6 gave the following results :—

R.p.m.	B.H.P.	Cub. ft./B.H.P.	Ignition timing.
1500	19·5	26·35	1° after T.D.C.
1500	19·5	26·75	6° before T.D.C.
1500	19·15	27·25	11° ,, ,,
1500	18·35	29·40	16° ,, ,,
1500	17·78	31·2	21° ,, ,,
1500	16·72	34·7	26° ,, ,,
1500	14·68	38·3	36° ,, ,,
1500	12·50	44·8	46° ,, ,,

Following this test attempts were made to recover part of the power loss at the advanced ignition settings by readjusting the air/gas ratio delivered by the carburetter, but no significant improvement could be obtained.

It appears therefore that though it is possible on gas to obtain higher thermal efficiencies by working with weak mixtures and a large ignition advance, this result can only be obtained at the expense of power output which cannot be afforded in the general conversion.

(To be continued.)

Powdered Metal and Bakelite Bearings*

These bearings are normally manufactured from bronze powder of the copper-tin class, although they can be made from ferrous material. The powder is placed in a mould and compressed to shape under pressure; on removal they are usually sintered. which hardens them. It is not advisable to machine them unless the operation is confined to reamering the bore when in position. If they are machined there is a tendency for the tool to tear particles out instead of cutting through and this rather gives the appearance of faulty material.

The oil-impregnated type is manufactured in a similar way to that described above. After the sintering process the bearings are immersed for a short time in a mineral lubricating oil and heated to a temperature of from 110 deg. to 120 deg. Cent. and cooled off in cold oil. These bearings usually contain 30–40 per cent. of lubricant by weight. This process can be used to re-impregnate bearings that have lost their oil from prolonged storage or any other cause.

It is not advisable to use emery paper or other abrasive in fitting this type of bearing, as owing to the cellular or porous nature of the material the small particles of abrasive will enter the pores and act as a lap with disastrous results to the shaft. A fine file or scraper should be used to remove burrs or form small radii.

The advantages of employing this type of bearing in places where lubrication is difficult is obvious. Lubrication is automatic and continuous, and varies with the pressure and temperature of the bearing. Oil grooves within the bearing can be eliminated. Some types of sintered bearings are rather brittle and will break or crack if subjected to shock. The oil-impregnated type does not suffer from this fault to the same extent. Nevertheless, it is highly desirable that they should be forced home into their housings with the aid of a mandrel to ensure true alignment when being inserted.

There is no surplus oil to cause splashing with consequent damage to manufactured products. Neither is there any risk of seizure since the lubricating film is always existent between the surfaces, this film adjusting itself automatically according to the pressure and the temperature of the bearing.

Synthetic resin and resin-bonded fabric materials of the phenol formaldehyde type have gained a certain amount of popularity for bearings where heavy pressures obtain, such as roll neck bearings in rolling m lls. They are made from laminated fabric which has been impregnated with synthetic resin. The material is generally made in b'ocks from which the bearing itself is machined. This makes a very strong job, and will stand considerable pressure. Owing to the low factor of heat conductivity it is usual to lubricate these bearings with water to carry away the heat.

Smaller bearings or bushes can be moulded from the synthetic resin material itself, but it has little strength. Experiments have been made to improve the strength of this material by the use of metal fillers instead of wood fillers and also by shredded fabric.

Bearings made with a metallic filler or strengthener were found to be little better than the resin itself owing to the fact that the resin did not bond itself into the metal.

Bearings made from resin having shredded fabric intermixed gave much better results; but it would appear that if strength is desired it can only be obtained by winding woven fabric on a mandrel of the desired size before impregnating. Bearings made in this way will stand up to most duties within the bounds of their limitations. The material is

* From a paper, "Bearing Metals and their Suitability for Modern Requirements," by M. Melhuish, published in the *Journal* of the Institution of Automobile Engineers.

light, takes on a good finish which is an essential feature of a good bearing, possesses a low coefficient of friction, and by using the modern resins can be lubricated with oil. It is doubtful, however, whether this material will be developed to such an extent that it will become a serious competitor to other bearing materials now in use in internal combustion engines.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

FLUORESCENT AND PHOSPHORESCENT PAINTS FOR A.R.P. PURPOSES

B.S./A.R.P. 18. This specification was originally published in December, 1939, and is one of a large number of specifications for A.R.P. purposes published at the request of the Ministry of Home Security by the Institution since the outbreak of war. The main points of difference between the latest issue of the specification and the earlier edition are the extension of the specification to cover paints other than those giving a greenish light and the inclusion of a simpler form of brightness test as an alternative to the visual brightness photometer method. The latter, it was always realised, has proved difficult for laboratories not specially equipped for the work of measuring brightness of the order of 0·001 equivalent foot-candle. Another interesting feature is the adoption for the purposes of this specification of a unit referred to as effective brightness which takes the place of the more usual unit of equivalent foot-candle. The unit of effective brightness is defined in the specification as follows :—

Unit of Effective Brightness.—A unit of brightness in common use is the equivalent foot-candle which is defined, as the brightness produced by an illumination of 1 foot-candle on a perfectly diffusing surface having a reflection factor of 100 per cent., comparisons of differently coloured surfaces being made at values of brightness sufficiently high to ensure that the observer's eye is in a state of light adaptation. Owing to the fact that at low brightness the eye becomes progressively more and more blue-sensitive, the judging of the merits of differently coloured luminescent paints on the basis of their equivalent foot-candles does not give a true measure of their relative practical usefulness. It is necessary, therefore, in measurements of coloured light made at brightnesses of less than one equivalent foot-candle to define precisely the basis of such measurements. The basis adopted in this specification is visual comparison of any surface with a white diffusing surface illuminated by light from a tungsten filament lamp operating at a colour temperature of 2360 deg. K., the brightness of the white surface in equivalent foot-candles being defined as the product of its reflection factor ρ and its illumination in foot-candles. This illumination is found by dividing the candle-power of the lamp (I) by the square of the distance of the lamp from the surface in feet (d). The brightness of the white surface is therefore $\rho \frac{I}{d^2}$ equivalent foot-candles, and any coloured surface, judged by a normal observer to be equally bright, is said, for the purposes of this specification, to have an effective brightness of $1000 \times \left(\rho \frac{I}{d^2}\right)$ units provided that the areas of the surfaces compared subtend an angle of at least 5 deg. at the observer's eye. The reason for this stipulation lies in the fact that for low brightnesses and small angles of view the effective brightness observed depends to some extent on the magnitude of the angle that the surface subtends at the eye. It will be seen that the unit of effective brightness thus defined is equal to 0·001 equivalent foot-candles for light having a colour temperature of 2360 deg. K.

NOTE.—The unit of effective brightness may be stated in terms of other units, for light having a colour temperature of 2360 deg. K., as follows :—1·0 unit of effective brightness is equal to 0·001 equivalent foot-candles, 0·001 foot-lambert, 0·001076 millilambert, 0·000318 foot-candles per square foot.

Copies of this revised B.S./A.R.P. 18 may be had from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 1s. 3d. post free.

FABRIC-BITUMEN EMULSION TREATMENT FOR ROOF GLAZING

BS/ARP 48. The problem of efficiently treating roof lights, particularly in large industrial buildings, has been a very acute one under present conditions. The British Standards Institution has just issued this specification in the A.R.P. series. It recommends a form of treatment which not only provides adequate black-out, but also affords continued protection for several weeks should the glass become broken. It consists of a bitumen emulsion with an interposed layer of fabric. The Standard not only describes the method of application, but also indicates the requirements for a suitable emulsion and the type of fabric to be used.

Copies of BS/ARP 48 may be obtained from the British Standards Institution, 28, Victoria Street, S.W.1, price 8d. post free.

ALUMINIUM BARS CONTAINING SMALL PROPORTIONS OF COPPER

B.S. 918—1940. This War Emergency Standard deals with aluminium bars containing small proportions of copper. This material formed the subject of a specification in the aircraft series No. L.34. This has now been withdrawn and will be replaced by the War Emergency Standard which has been extended in its scope to apply to all branches of engineering. It is realised that there are still certain problems associated with the development of this material, and for this reason the specification has been included in the War Emergency series. It will be the subject of review and modification after the end of the war.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Iron and Steel in the United States

The iron and steel market in the United States is active and the demand has strengthened under the influence of the rearmament programme. In the pig iron section deliveries are on a considerable scale and the current blast-furnace output is booked for some time ahead. It is expected that new buying will shortly develop and that this will ensure the rate of delivery being maintained in the last quarter of this year and the first quarter of 1941. The rise in scrap prices has led to more pig iron being used, but business is chiefly of a domestic character and the export demand remains featureless. The machine tool industry, which has been supplied with large orders on account of the rearmament programme, is operating at 93·8 per cent., and it is estimated that big tonnages of cast iron water pipe will be required for the camps and permanent quarters of the troops called up for training. The advance in the prices of scrap has brought the quotation to 20·50 dollars to 21 dollars, d/d. Railroad No. 1 selection is quoted at 22 dollars and railroad specials up to 25 dollars. The Eastern Pennsylvania quotation is 19·50 dollars to 20 dollars. A large proportion of Japan's purchases in the early part of this year of 350,000 tons has not yet been delivered. The production of steel for the whole country averages 91·90 per cent. of ingot capacity. The Detroit district is operating at 97 per cent. and Birmingham at 93 per cent. capacity. Operations at the tin-plate mills have declined to 43 per cent. Export buying of tin-plates is much lighter, partly because the Mediterranean market is closed. Railway buying is expected to develop shortly. One important railway is in the market for 65,000 to 75,000 tons of rails for 1941 delivery. Bookings of constructional steel for the three or four weeks ending September 15th amounted to 15,000 tons weekly and was required principally for Government work.

The Pig Iron Market

In the pig iron market conditions seem to be fairly comfortable. Foundry iron is in good supply, although there is some tightness in supplies of low-phosphoric foundry iron. The foundries, however, are getting regular supplies of the descriptions they need, although there is some complaint that iron required for mixing purposes is not always available in the particular description asked for. The tendency is for the needs of all consumers to increase, but the licences for supplies for the last quarter of the year have already been issued to consumers. Hematite is in better supply than for some time, but the demand for this description appears to be decreasing. Larger supplies of ore and other raw materials have enabled furnaces to operate at capacity. In the Midlands all the blast-furnaces are actively employed, and not only do they have to cater for the requirements of the foundries in the Midlands, but they have to send considerable quantities to consumers on the North-East Coast. The possibility that higher railway rates will cause an increase in pig iron prices has not been lost sight of, and sales are made with a clause in the contract entitling them to payment at the price ruling when the iron is despatched from the makers' works. Light casting foundries could still undertake more work than comes their way and their demands are scarcely sufficient to take care of the output of high-phosphoric iron. Engineering foundries are taking large supplies of low-phosphoric and hematite. In Lancashire the jobbing foundries appear to be well employed and are using good tonnages of foundry iron. There is also a steady demand for forge qualities in the Lancashire district. Good supplies of iron ore are reaching this country and the furnaces in Scotland are operating at a high rate, but the whole of the foundry iron produced is passing at once into consumption. The basic iron situation has been improved by imports from abroad, and at the same time there is a heavy output from the home furnaces.

Scotland and the North

The production of iron and steel by the Scottish steel works is on a high scale, and great efforts are being made to increase output. The demand is as great as ever and consists mostly of urgent requirements. The supplies of raw materials are adequate to the works needs, and this enables the high rate of production to be maintained. All the steel works are heavily booked for some time ahead, and consumers are continually pressing for deliveries. The call for joists and sections is unrelaxed and large tonnages are going to the constructional steel works and the shipyards. Big quantities of plates also are required, chiefly on account of Government orders, and in this department the stringency does not seem so noticeable as during recent weeks. So much of the work now being turned out by the large consumers of iron and steel comes into the category of national importance that the steel makers have little respite from the intensive working conditions which have ruled in the industry for many months. The demand for special and alloy steels appears to be increasing, and the requirements of the firms engaged upon armament or munitions work absorb all this class of steel produced. The locomotive engineers, tank makers, and wagon builders are fully employed, and are taking up large tonnages of various forms of finished steel. In the Lancashire market there is an active demand for steel of all descriptions. There is a strong request for plates, and the situation in this department appears easier since large tonnages are understood to have been delivered recently to the tank and boilermakers. The requirements of consumers of steel bars are heavy, and important tonnages of large and small sizes are passing into consumption. The demand for semis continues strong, and lately imports from the United States have helped to ease the position.

The North-East Coast and Yorkshire

The steel situation on the North-East Coast has not materially changed. All the works are operating at capacity and all the available plant has been brought into operation. The raw materials position also is quite satisfactory and this has helped to maintain outputs at a very high level. At the same time, the demand for all descriptions of steel has increased and appears to be growing, so that notwithstanding the high rate of production the pressure upon the steel makers for deliveries is unrelaxed. The improvement in the position of the re-rollers has been maintained and there seems to be no lack of billets and sheet bars to meet their requirements. This is due to heavy importations from the U.S.A. There is, however, still some tightness in the supply of 1¼in. and 2in. billets, but this, it is understood, will be only of a temporary character. There is a heavy demand for structural steel, which is being used by the constructional engineers in large quantities. Whilst it is difficult to obtain material for non-essential purposes, firms employed in national work are receiving full supplies. It is expected that the revised steel distribution scheme will conserve steel for use for essential purposes and that the tightening up of the regulations will lead to more steel being available for war purposes. In addition to the pressure to obtain deliveries of joists and sections, makers have to meet strong demands for shell steel from munition works and large quantities are passing into consumption. Yorkshire works are experiencing pressure from consumers as severe as that in other parts of the country. The strong demand for basic steel continues unabated and the works have heavy order books. The production of acid carbon steel has been increased and it appears to be meeting the demand fairly well. Sheffield works are producing large outputs of acid steel as well as considerable tonnages of alloy steels, and special steels for armament purposes. There is also a comparatively big tonnage of steel for aircraft purposes being turned out.

Copper and Tin

The situation in the copper market shows no important change. Not only are deliveries reaching the consuming works with regularity, but an increased demand is in evidence and this is being adequately met by the Control. The active buying in the United States has been maintained and the American domestic sales during September are reported to have reached the unprecedented monthly total of 255,332 short tons. Producers in the United States are selling cautiously, as they fear that some of the demand is in anticipation of the requirements of the American rearmament programme and does not represent current needs. Prices for domestic delivery are steady at 12c. d/d, whilst the export quotation remains at 9·90c. Japan has been in the market and is reported to have offered up to 10c. in an effort to obtain the copper required, but there is great difficulty in obtaining copper for near delivery. The Ministry of Supply has issued a notice stating that under the Defence (General) Regulations, 1939, the Minister has requisitioned further tonnages of copper lying in warehouses and wharves in this country. The names of the warehouses and wharves are stated below and owners of copper lying at these places should inquire whether their metal has been requisitioned. This follows the requisition made in July, when copper lying in Messrs. Weber, Smith and Hoare's Metropolitan and New Crane Wharf was taken over. The wharves and warehouses are :—Henry Bath and Son, Ltd., Liverpool; Colonial Wharves, Millwall Wharf, Orchard Wharf, London; Fellows, Morton and Clayton, Ltd., Birmingham; Tyne Improvement Commission Warehouse, Newcastle-on-Tyne; Thomas Cheshire and Co., Ltd., Henry Diaper and Co., Liverpool. Applications for compensation should be sent to the Controller, Non-Ferrous Metals Control, Grand Hotel, Rugby. Invoices and warrants should be sent with the application. The prices (per ton) of requisition are :—Rough copper, £54, London Metal Exchange standard copper contract terms; fire-refined copper, £57 10s. net; electrolytic copper, wire bars or ingot bars, £59; cathodes, £58 10s. Rent should be deducted on the invoice up to and including September 23rd, 1940. . . . The tin market has been rather quiet, the general view being that the future of this market is somewhat uncertain. For one thing, export licences to the United States are only issued for November and onwards shipment. Mr. W. H. Gartsen's statistics of tin give the visible supply at the end of September as 34,498 tons, compared with 32,250 tons at the end of August. The supplies during September were 16,367 tons, compared with 15,002 tons, and the deliveries 14,119 tons, against 15,411 tons during August.

Lead and Spelter

The situation in the lead market so far as supplies are concerned remains comfortable. Consumers are obtaining all the metal they need and are using large tonnages. The impression prevails, however, that lead is used to a smaller extent in this war than the last. The supply position is easy and it is possible to release metal for ordinary industrial purposes and also for the manufacture of exportable products. In the United States the demand has strengthened and prices are firm. This is partly due to the American rearmament programme, although so far this does not appear to have had any direct effect upon the market. Stocks of lead in the United States at the end of August amounted to 47,000 short tons, which was estimated to be about one month's normal supply. No doubt the possibility of the position becoming stringent has had something to do with the firmer conditions in the United States. . . . The demand for spelter shows no signs of diminishing, but supplies are sufficient to meet the requirements of all firms engaged in war work. The consuming industries appear to be well supplied with orders and the galvanising trade has lately bought with some freedom. The die castings industry also is working at capacity and is taking up good quantities. The American market has developed considerable strength, principally because of the orders placed as a result of the American rearmament programme. It is expected that as time goes on the Government purchases will have an increasing influence upon this market.

Notes and Memoranda

Rail and Road

Railway First Aid.—Despite the heavy war-time calls made upon the railways, the L.M.S. states that 8846 of its employees have passed proficiency examinations in ambulance work during the current year. This compares with 6183 fifteen years ago. London had 1001 "passes," Manchester 715, and Derby, Nottingham and Sheffield 1080.

Electrified Railways in South Africa.—Following the electrification of a mineral line joining Canada Junction with Jupiter, through the southern suburbs of Johannesburg, electric traction is now employed on the section between Canada Junction and Village Main. The total mileage of electrified railway lines in the Union now amounts to 605 route miles, equivalent to 1232 miles of single track.

The Acquisition of New Cars.—Only persons engaged in work of vital national importance will, in future, be able to obtain a licence to acquire an unregistered car. This decision follows an announcement by the Ministry of Transport in July last that, as it was in the national interest that all unregistered cars which could be exported should be exported, no licences to acquire new cars would be issued by the Ministry of Transport until the Board of Trade had explored, jointly with motor traders, the position in respect of cars in the hands of dealers and manufacturers. This survey has been carried out and it appears that the number of cars which cannot be exported and which are therefore available for civilian use is very small indeed.

Pre-cast Concrete Bridge.—What is claimed to be the world's largest pre-cast concrete bridge span has just been completed by the Canadian National Railways on the island of Montreal. The span of the bridge is 77ft. and its width is 27ft. to allow for the two-track main line at this point. The bridge slabs, four in number, were pre-cast in the C.N.R. yards, which are west of the site. All the metal tie plates and lifting loops were cast in the concrete. Each slab weighs approximately 270,000 lb. The actual time taken to erect the slabs was four days and all work was done between the regular train movements, so that there was no interruption in traffic. Mr. C. P. Disney, bridge engineer for the C.N.R., was responsible for the design of the structure and the erection.

Dominion Timbers.—The United Kingdom imports of railway sleepers from Canada have grown during the last few years from 10,943 standards in 1936 to 37,064 standards in 1937 and 29,282 standards in 1938. In that period the proportion derived from Canada rose from 12½ to 25 per cent. Creosoted railway sleepers of Douglas fir are a speciality of British Columbia. Other timbers which are growing in importance under present conditions are coming from Malaya and British North Borneo. White Seraya wood is used for ships' decking and in railway wagons. Borneo camphorwood and red Seraya are employed for flooring and constructional work. British Guiana is the chief source of supply of greenheart, favoured for wharves and piles, owing to its resistance to marine borers.

Regirdering Nerbada Bridge.—A contract has recently been let to the Braithwaite, Burn and Jessop Construction Company, Ltd., for the regirdering of the last bridge in the Bombay, Baroda and Central India Railway bridge strengthening programme. This bridge is over the Nerbada River at Mortakka, on the metre-gauge section between Mhow and Khandwa, the existing structure consisting of fourteen spans of 189ft. and two plate girder shore spans. The track is carried on the top chords and a highway on a deck between the lower chords. The new structure, states the *Railway Gazette*, will consist of fourteen spans, each of 193ft. 10in., with two plate girder shore spans of 37ft. 6in., without a highway deck. Arrangements are being made by the Holkar and Central Provinces Governments jointly to build a submersible road bridge in order to preserve the long-established road crossing of the river at this point.

Air and Water

The "Flying Fortress."—It is stated in *Flight* that the Boeing "B-17B," known as the "Flying Fortress," has been placed on the export list and will be available for sale to this country. Its total loaded weight is 37,000 lb. and it has a span of 103ft. with a length of 68ft. Its speed is given as 268 m.p.h. at 14,000ft., and it has four geared Wright "GR-1820" engines rated at 1200 H.P. for take-off. Range is given as 4200 miles and service ceiling as 29,300ft.

Assuan Dam Power Scheme.—It is reported that the Egyptian Cabinet has decided to carry out the Assuan Dam power scheme drawn up two years ago, which was thought to have been permanently shelved on the outbreak of war. The scheme was previously estimated to cost £E7,000,000, but now, owing to increased prices, the outlay will be larger. The work will be carried out by British contractors and will provide for the manufacture of artificial fertilisers and ammunition.

Mercantile Losses.—Mercantile losses due to enemy action for the week ended September 30th, 1940, were:—British, ten ships total tonnage 55,927: Allied, four ships 12,119 tonnage, Neutral one ship of 4291 tons. Corrections to previous weeks are announced as follows: 54th week, September 9th to 15th, British losses should be amended to eleven ships totalling 44,603 tons, and for the 55th week, September 16th to 22nd, 20 British ships totalling 134,975 tons, and six Neutral ships of 24,486 tons total.

China Builds Motorships.—The Hong Kong and Whampoe Dock Company, Ltd., has built a motorship for Norwegian owners in its own yard, where the machinery was also constructed. Its engine is the highest powered marine oil engine yet manufactured in China. The ship has a deadweight capacity of 2600 tons, and will have a speed of 12 knots. The engine, manufactured under licence from Messrs. Harland and Wolff, is a two-stroke, single-acting, five-cylinder type, with cylinders having a diameter of 500 mm. and a piston stroke of 900 mm. The output is 1700 B.H.P. at 160 r.p.m. The "Hermelin," as the ship is called, is to operate on the China coast, with voyages also to Singapore and Bangkok.

Aeroplane Work in Canada.—Excluding Canadian Associated Aircraft, Ltd., which is engaged in assembling aeroplanes for the British Government, more than 8400 employees are now at work in seven Canadian aircraft plants. Many are engaged in other aircraft plants and elsewhere, producing aircraft components, such as wings, undercarriages and spars. Still others are working on the assembly and the manufacture of aircraft equipment and parts. In all, some 17,000 Canadians are now engaged on the Canadian aircraft production programme.

Asphalt Technology.—Several U.S.A. highway authorities are co-operating with the Association of Asphalt Paving Technologists, which will hold a National Asphalt Conference at Dallas, Texas, during the week of December 9th. Some 2000 engineers, technologists, contractors and representatives of the petroleum industry are expected, and owing to the widespread use of asphalt in airport construction, supplementing its major use in the surfacing of highways and streets, the Conference will stress the subject of national defence from a highway and airport angle. Asphalt as a means of preventing erosion of river banks and lake shores, and in the lining of canals and ditches, will form an interesting feature of the Conference.

Work in Cuba.—Two years ago negotiations were in progress between Cuban shipping interests and British shipbuilders for the construction of between fourteen and seventeen vessels, together with a floating dock, the orders being valued at £3,000,000. It was understood at the time that the Cuban Government had accepted the British plans, and that, but for the war, a British representative would have left for Cuba. Now it is reported from New York that a Bill was introduced in the Cuban House of Representatives at Havana, in August, which would authorise the development of a Cuban merchant marine under a national subsidisation plan. The measure would provide a guaranteed 10 per cent. preference in Government freight and ocean mail contracts and five-year tax exemption. The scheme would provide also for a minimum of twelve cargo vessels of 2000 tons or more under the Cuban flag with Cuban crews.

Miscellanea

Ban on Scrap Export.—President Roosevelt has declared an embargo as from October 15th on the export of iron and steel scrap to all countries except those of the Western Hemisphere and Great Britain.

South African Tin.—The Zaaiplaats Tin Mining Company has announced particulars of its operations for July, when the output was 15·5 long tons of tin concentrates of an average assay value of 71·36 per cent. metallic tin.

Strontium in India.—Deposits of high-grade celestine and strontianite have been discovered at Utatur (Trichinopoly) as the result of recent investigations. In view of the fact that no deposits of strontium minerals of any magnitude have been hitherto found in India, the discovery is of importance.

Japan Subsidises Research.—The Japanese Ministry of Commerce and Industry proposes to subsidise the study of the manufacture of certain types of machinery for which Japan has in the past been largely dependent upon imports, and also to subsidise the production of iron and steel works plant and machine tools.

Material for Engineering Classes.—Wherever possible scrap material is to be used for workshop training in technical colleges, and local education authorities have been asked by the Board of Education to make every effort to obtain it from local supplies. Where that is not possible, the material can be requisitioned in the usual way, but the metal then has to be taken from the quota assigned to the Board. After use the material should be returned again as scrap.

To Train Royal Engineers.—Birmingham University has been selected for the training of men for commissions in the Royal Engineers under the War Office scheme. The young men will undergo a six months' course in engineering, and the first group, consisting of thirty to forty men, is to start this month. The second group will begin in April next. A special course has been devised for the students. When the educational course is over the men will go to Officer Cadet Training Units.

New Government Appointments.—Following the resignation of Mr. Neville Chamberlain, certain changes in the Government were announced on Friday, October 4th. The size of the War Cabinet has been increased from six to eight, Sir John Anderson taking the place of Mr. Chamberlain as Lord President of Council, and Sir Kingsley Wood and Mr. Ernest Bevin also being included. Sir Andrew Duncan becomes Minister of Supply and he is succeeded at the Board of Trade by Captain Oliver Lyttelton. Mr. Herbert Morrison is appointed Home Secretary and Minister of Home Security. Sir John Reith becomes a Baron and is appointed to a new office, Minister of Works and Buildings. He is succeeded at the Ministry of Transport by Lieutenant-Colonel J. T. C. Moore-Brabazon.

Scrapped Railings.—Since the "Railings for Scrap" campaign was inaugurated in May, 424 local authorities have contributed 22,000 tons of the best quality wrought and cast iron scrap to the steel works. In addition, 547 Councils are now surveying all available railings on their property or are considering reports of surveys in committee. This average of 1000 tons per week has been practically all obtained from properties owned by the local authorities, but at Bolton, Oxford, Glasgow, Newcastle and a number of other places privately owned railings have been contributed. Both his Majesty's Office of Works and Liverpool Corporation have contributed over 1000 tons and Birkenhead, Birmingham, Bolton, Manchester and Oxford over 600 tons each. In Manchester a profit of £896 has been made from the sale of the railings from twenty-five parks, and in Harrogate nearly 50 tons were sold, giving a profit of £138.

A.R.P. Rescue Training.—The City Press of Chester has prepared a booklet under the foregoing title and has sent us a copy for review, with the information that four editions have already been completely sold to public bodies. The booklet (price 8d. post free) was compiled by and originally produced for the Surveyor's Department of the Cheshire County Council. It deals with the duties of rescue parties and gives instruction regarding the appliances and tackle that are likely to be used. There are numerous illustrations. Some of the headings of the various sections will give some idea of the ground covered: Ropes, Knots and Lashings; Block and Tackle and Levers; Shears, Gyns, Derricks, Jacks, Winches, &c.; Shores, Strutting, &c.

Personal and Business

A. C. Wickman, Ltd., informs us that on October 8th there was opened a branch office at Leeds. The address is A. C. Wickman, Ltd., Lloyds Bank Chambers, Vicar Lane, Leeds, 1.

British Mission to South America.—A mission being sent to South America by H.M. Government to explain the present British economic policy and to promote our export trade is to include Mr. C. S. Richards as representative of the electrical industry. Mr. Richards is joint managing director of Metropolitan-Vickers Electrical Export Company, Ltd., and a director of Metropolitan-Vickers Electrical Company, Ltd. He has been in direct association with the South American market, of which he has made a special study, over a number of years.

The Late Mr. J. W. Downie.—Mr. John Wallace Downie, C.M.G., died recently at Salisbury, Southern Rhodesia. Born in Glasgow in 1876, he went to South Africa when he was twenty-one years old to join the Cape Government Railways, his work being connected with the railway line which was being constructed through Bechuanaland to Bulawayo. In 1900 he returned to Glasgow, but a year later he was back in Rhodesia and associated himself with several business and mining concerns. In 1924 he entered Parliament after the grant of responsible government to Southern Rhodesia, and eventually became Minister of Mines and Public Works. In 1931 he was appointed High Commissioner in London for Southern Rhodesia. When his period of office expired he became chairman of the Rhodesia and Nyasaland Airways until the outbreak of war, when he was appointed Controller of Supplies for the Colony.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Bradford Engineering Society

Monday, October 14th.—Technical College, Bradford. "The History of the Woolcombing Machine," H. Baxter. 7.15 p.m.

Illuminating Engineering Society

Tuesday, October 22nd.—E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, W.C.2. "Industrial Lighting in War Time," H. C. Weston. 2.30 p.m.

Institute of Fuel

Thursday, October 17th.—Connaught Rooms, Great Queen Street, London, W.C.2. Presidential Address, W. M. Selvey. 2.15 p.m.

Institute of Transport

Monday, October 14th.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "The Reconstruction of Transport Policy," F. Smith. 5.30 p.m.

Institution of Civil Engineers

Saturday, October 12th.—Yorkshire Assoc.: Grand Hotel, Sheffield. Chairman's address, A. G. Beaumont. 2.30 p.m.

Institution of Electrical Engineers

Wednesday, October 23rd.—S. Midland Students: James Watt Memorial Inst., Great Charles Street, Birmingham. "Continuity of Supply," D. H. Ray. 6.30 p.m.

Thursday, October 24th.—Savoy Place, Victoria Embankment, W.C.2. Presidential Address, J. R. Beard. 2.30 p.m.

Institution of Mechanical Engineers

Friday, October 18th.—Storey's Gate, Westminster, S.W.1. Presidential address, "Mainly the Port of London," Asa Binns. 2.30 p.m.

Institution of Structural Engineers

Saturday, October 26th.—Yorkshire Branch: Hotel Metropole, Leeds. "The Channel Tunnel," T. J. Gueritte. 2.30 p.m.

Iron and Steel Institute

Tuesday, October 15th.—Modern School, Cole Street, Scunthorpe. "Anti-piping Compounds and their Influence on Major Segregation in Steel Ingots," E. Gregory. 7.30 p.m.

Manchester Association of Engineers

Saturday, October 12th.—Engineers' Club, Albert Square, Manchester. Presidential address, A. C. Dean. 2.30 p.m.

Saturday, October 26th.—Engineers' Club, Albert Square, Manchester. "Principles and Applications of Automatic Temperature Control," M. J. Gartside. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, October 18th.—Literary and Philosophical Society, Newcastle-upon-Tyne. Presidential address, W. A. Woodeson. 6 p.m.

Wednesday, October 23rd.—Student Section: Bolbec Hall, Newcastle-upon-Tyne. Chairman's address, G. Wright. 6.45 p.m.